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A PRACTICAL METHOD FOR DETERMINING OCEAN CURRENTS

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FOREWORD

The following paper has been compiled from a series of lecture notes made by the writer when he took an advanced course on oceanography under Prof. Björn Helland-Hansen, Geo-Physical Institute, Bergen, Norway. Writers of textbooks on oceanography, fail from time to time, due to the rapid growth of this science, to keep pace in print with the newest methods in practice. The need for the appearance of the present treatise is emphasized when it is realized that a complete exposition of the methods elucidated herein has never before, to the writer's knowledge, been collected in a single publication, and the particular hydrographical information, prior to this, has been unavailable short of personal instruction in Europe. Although the illustrations to be found throughout the paper are in most cases examples taken from observations of the International Ice Patrol off Newfoundland, and although the bulletin is intended especially to assist the prosecution of Ice Patrol service, the application of the text is, nevertheless, quite broad in its scope. It is therefore recommended to the attention of all students interested in the subject of physical oceanography.

The foundation upon which this paper rests was first laid down by Prof. V. Bjerknes, (see "Dynamic Meteorology and Hydrography," Carnegie Institution publications, Washington, 1910-11). In the lines of history which record attempts to apply mathematics to the natural sciences this treatise by Bjerknes stands out as one of the most successful and progressive. A perusal of the book can not fail to impress one with the infinite care and exactitude with which the theories have been presented and the exposition developed. It is a model of scientific treatment, but he who is searching for a practical method directly applicable to a hydrographical problem is bound to note the absence of just this sort of pertinent information. Since the time when Bjerknes' theories became recognized by scientists there have been a few oceanographers, especially Helland-Hansen, Nansen, Ekman, and Sandstrom, who have done much to give the formulæ of motion a practical application to the sea. As a result of such development we are now supplied with a scientific method whereby if the temperature and salinity of the ocean are given from several known depths and stations the direction and velocity of the currents even in the deep water off soundings can be computed and mapped. In this connection it may be of interest to know that the currents calculated from the observational data collected in 1922 off the Grand Banks have been found to agree very closely with the drifts of the icebergs of that same year and region.

This paper endeavors to encompass in a general way the foregoing subject with its various aspects. The contents deal with the following: The causes of currents; static consideration of a water mass; dynamics and Bjerknes' theory; and a practical method for mapping currents. Other related subjects discussed are friction; effect of bottom configuration; tides; variations in atmospheric pressures; and the winds. The writer has tried to present a rather technical scientific subject in such a manner that it may easily be understood by the ordinary student. Always there has been the hope that the methods elucidated herein would serve some practical economic service.

I wish to recognize with appreciation the advice and suggestions made with regard to this paper by the curator of the Museum of Comparative Zoology, Harvard University, and the hydrographic engineer, United States Hydrographic Office.

The foreword is not complete unless this place is reserved to express a sincere appreciation and acknowledgment of the untiring, generous assistance and instruction given me in this work by the director of the Geo-Physical Institute, Bergen, Norway. He has in many instances placed even his personal notes at my disposal, and in a hundred other ways has shown an unselfish spirit of cooperation and friendship. As I leave Norway I bid him a fond farewell.

E. H. S.

August 13, 1925.

A PRACTICAL METHOD FOR DETERMINING OCEAN CURRENTS

EDWARD H. SMITH

THE ORIGIN OF CURRENTS

In order to make a systematic exposition of the circulation taking place in the oceans with especial regard to the origin of currents, we have found it convenient to divide the forces into two general classes: (1) Internal and (2) external.

(1) *Internal forces* appear in an ocean mass whenever any change takes place in the physical character of the water itself; that is, if either the temperature or the salinity varies in the sea then the dynamic equilibrium is upset and a tendency to readjust must follow. The internal system of forces in an ocean are disturbed whenever that mass radiates or absorbs heat; evaporates from the surface; receives additions of fresh water; or suffers internal physical transformation as a result of its turbulent activity. Radiation is simply a gain or loss of heat by the ocean, which tends to vary the temperature of the surface layers. Evaporation tends to vary the salinity of the surface. The ocean receives fresh water from rain, snow, or melting ice. When an ocean mixes internally it alters its physical character within the region of mixing.

(2) *Forces classified as external* and provocative of currents are winds, tides, and variations in atmospheric pressure. The winds we shall divide into two groups, determined primarily by their extent and duration: (*a*) Those winds which by a tangential pressure on the surface of the sea frictionally propagate a pure wind current only; and (*b*) those winds which by virtue of friction drive water particles against boundary surfaces in the sea and give rise to gradient currents. Winds classified as (*b*) are by far the most important of the external forces assisting to maintain the more or less prevailing system of circulation in the oceans.

There are, however, two other forces which are classified as secondary, but only in so far as they tend to deform the components established by (1) and (2). They are, nevertheless, of the utmost importance in the consideration of currents, namely, (*a*) the quasi force due to terrestial rotation which acts simultaneously as soon as a movement as described in paragraph (1) or (2) begins; and (*b*), fric-

tion, that due primarily to land and bottom configuration as it tends to guide and shape the direction as well as to effect the velocity of ocean currents. Friction also is an important factor, arising whenever water particles of dissimilar motions interact among one another. A well-known example of this process is contained in the waters of a mixing zone which lies adjacently inshore of the Gulf Stream and stretches along the American continental slope.

It is difficult, even in such a well-known current as the Gulf Stream, to state which class of forces, internal or external, is the fundamental cause of movement, yet the subsequent forces tending toward alterations of the movements spring from two influences—friction and rotation of the earth. A discussion of some of the foregoing features will assist to a clearer understanding of the entire subject.

STATIC CONSIDERATION OF A WATER MASS

Let us imagine that we can pass a plane vertically downwards through the ocean and can regard a cross section of the water in profile, with a view to studying its static condition, or distribution of mass. If now the water particles could be colored with reference to their relative weights, we would find the lightest water in the surface layers, and the heaviest particles on the bottom. The two fundamental essentials usually determined and which lead to hydrostatic examination are temperature and salinity; once they are found the specific gravity (density) follows as a dependent from convenient hydrographical tables. It is often desirable to speak in terms of specific volume, it being the volume of a body per unit mass, or the reciprocal of the density. If d = density, and v = specific volume, then $v=\frac{1}{d}$. As an example of the contractions which are customarily adopted by practical hydrographers, we may have given, $d=1.02711$; this is written, for the sake of brevity, 27.11. The corresponding value of v in this case is 0.97361, and this is often shortened to a numeral of only three digits, viz, 361. The greater the specific volume at any point the lighter the water is there.

If now we return to our vertical section in the sea and connect all points wherein the water particles have the same specific volume for differences of every 10 units of the latter, we obtain a number of lines called isosteres running throughout the profile. An isoster is a line all points along which represent like values of specific volume; an isosteric surface merely increases the consideration to the two dimensions of an area. An isosteric surface may be visualized as spread out beneath the surface of the sea—an undulating floor whose depth can be determined with the same reality as the more tangible floor of the ocean is sounded out by the hydrographer.

THREE GENERAL STATIC CONDITIONS

There are three general static conditions revealed by vertical sections of the ocean arranged in accordance with a grouping of relative positions of the isosteric surfaces, and with reference strictly to the vertical. (1) The water may be found to have the same density throughout its column when compression is disregarded—i. e., homogeneous as to temperature and salinity. The specific volume in such cases, due to pressure, will necessarily decrease downward, thus it follows that the isosteric surfaces will be arranged solely in dependence with pressure. Such conditions may prevail at the end of winter when vertical convection has attained a maximum influence, or in the cases of strong winds which mix the surface layers, sometimes to a considerable depth. Such a water mass is homothermal and homohaline, and thus presents a consequent neutral

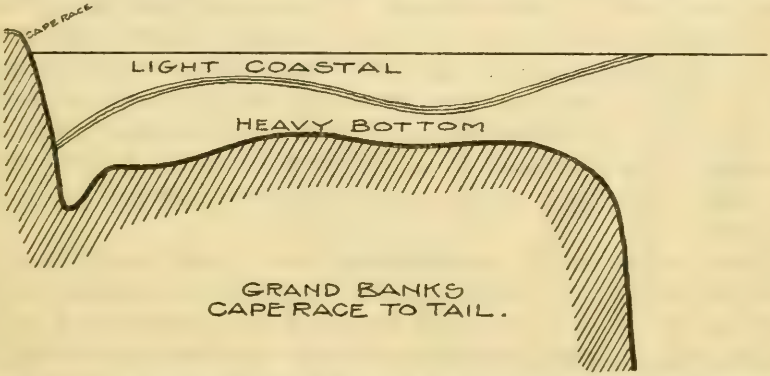

FIG. 1.—A type of stratified water mass found over the Grand Banks south of Newfoundland. The boundary of discontinuity between the two distinct layers is shown by the closely spaced parallel lines

equilibrium vertically. (2) When one homogeneous mass of water lies over another, then the water is in layers and is said to be stratified; it will be found that there are few isosteric surfaces in each layer compared with the number between two adjacent layers. An example of stratification often occurs in the column lying over the Grand Banks, when a cover of heavy water from the slopes is spread over the bottom; above this, and extending to the surface, is a layer of lighter, coastal water, maintained more or less homogeneous by the turbulent effect of the winds. (3) But the most common distribution in the sea is where the density increases proportionally and more or less regularly with the depth. The water in such cases is characterized by numerous isosteric surfaces lying in greater abundance at those levels where transitions of density occur; and this condition is termed stable. A direct measure of the stability of any water column is to be found in the number of isosteric surfaces in excess of that contained in homogeneous water per unit increase

in depth. The sea above the abyssal water, furthermore (with the exception of comparatively restricted places, such as a turbulent mixing zone during a gale), is in a condition pronouncedly stable. Winter cooling of the surface layers, it is true, sets up temporary, vertical, convectional currents, but this condition is short lived when we consider the entire year's span.

DYNAMIC CONSIDERATION OF A WATER MASS

In support of what has just been remarked, we might continue by regarding a vertical section of a stable water mass devoid of circulation. We will find the densest water rests on the bottom of the basin; the lightest water on the surface; and the isosteric surfaces will be exactly horizontal. If now a water particle from a bottom layer be shifted to the surface it will begin to sink to the isosteric sheet from which it was removed. A surface particle, just as truly, if submerged to the bottom will tend to rise and return to its former level. But if a sample be taken from one position to another position, all within the same layer, then there is no force giving rise to its return. It is obvious from this that water particles resist any tendency toward removal from their own particular isosteric sheet, but may move freely within such, if friction does not hinder the motion.

Every motion may be regarded simply as a displacement of masses, therefore a study of various types of distribution of mass in the sea is bound to reveal a vast deal regarding the currents, and in this respect the extreme importance of isosteric bounds governing the movements of the water particles can not be over emphasized. It will be seen, therefore, in the light of further remarks that once we have determined the general contour of the isosteric surfaces we have gained an insight, not only of the direction in which the water is moving, but also a measure of its relative rate of flow. The well-known principle of Archimedes is of great assistance in clarifying the components of the forces due to varying densities.

Let us again regard in profile a vertical section of any body of sea water wherein a distribution of density prevails from which dynamic variations may easily follow. Such a case may arise, as we have pointed out, as an effect of either one of two classes of forces. (See internal and external forces, page 1.) For example, imagine that the ocean has absorbed and mixed heat unevenly during the summer, causing the water to become lighter in a zone over a shallow coastal shelf than the water farther offshore; or perhaps an abnormal percentage of onshore winds have amassed a quantity of light water from the surface layers against a coast. Here, then, class (1) or class (2) forces have produced similar results which can best be examined by recourse to a vertical section normal to the coastal trend.

In Figure 2 the oblique lines are isosteres which have been formed by the intersection of the vertical plane of the section with the isosteric surfaces running through the water mass. The space between any two isosteric surfaces is called an isosteric sheet. The uppermost isosteric sheet on the left-hand side of Figure 2, in wedge-shaped form, bounds the body of lightest water that has accumulated against the coast. Now the water in the deepest portion of this isosteric sheet "A" is specifically lighter than the water *at the same level* in any of the other isosteric sheets, so according to the Archimedian principle this portion of sheet "A" will tend to be driven bodily upwards. The water in the highest portion of sheet "B" is specifically heavier than the water *at the same level* of the inshore sheet, and thus it will be dragged downwards. It is plain to see that

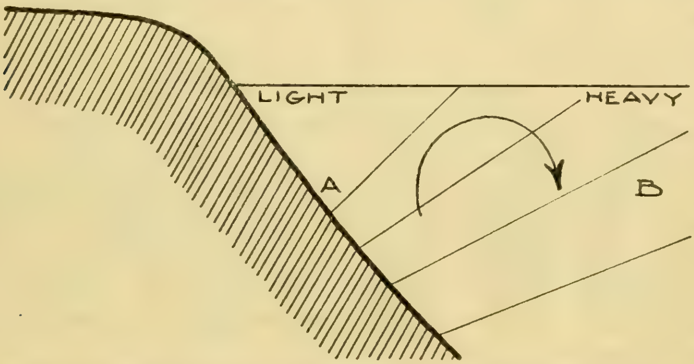

FIG. 2.—A vertical profile of a water mass showing a distribution of light and heavy water and dynamic tendencies which would prevail in such a state

there are forces tending to turn all the isosteric sheets into a horizontal position, and the greater the obliquity of the isosteric surfaces the greater the forces tending toward the leveling process. The water particles themselves, however, as a result of these stresses, will be forced from the thicker portion of the isosteric sheet to the thinner portion of it, the particles tending to keep, for reasons as pointed out in a previous paragraph, wholly within their own respective layer. When the sheets have attained a mean uniform thickness, then the isosteric surfaces have resumed the horizontal, dynamic equilibrium is established and circulation ceases.

The causes provoking currents were divided, it will be recalled, as being due to two classes of forces—viz, internal and external. The distinction between the two rests mainly on the manner in which energy is transmitted to the sea. This conception should be clearly understood.

(1) *Internal class of forces* refers to those agencies, the effects from which appear forthwith to alter the internal character of the water mass itself. This results in varying the distribution of density.

An example has been given when, by the absorption of heat, the water becomes lighter over a coastal shelf in summer.

(2) *External class of forces* can not possibly produce the slightest physical change in the character of the water particles themselves (when the turbulent effect of the wind is disregarded), but either they directly drive the water particles in a current or they deform a water mass that is qualified by boundary conditions. The latter type, similar to (1), tends to vary the distribution of density in the sea; an example has been given in the case of an onshore wind piling up the lighter surface water against a coast.

Thus we may sum up the distinction between the two classified origins of currents—viz, class (1) forces tend to alter the physical character of the sea water while class (2) forces tend either (*a*) to move the water particles in a current or (*b*) to deform eventually a given water mass.

THREE VARIABLES IN THE SEA

It is best to begin by treating the distribution of density in the light of mechanics and physics. We may regard each type as being a field of strain inherent to the mass itself, an effect of stresses, the fields of which in the sea can be treated when expressed in terms of three variables classified as follows: (1) *Gravity*, (2) *pressure*, (3) *specific volume*. Let us examine each one of the three variables separately and their combinations as they lead to dynamic measurement of currents.

First, however, it will be helpful to review some of the fundamentals elementary to a physical science. The three fundamentals in physics are MASS, LENGTH, and TIME, represented by the letters M, L, and T, respectively, and in these terms we may express any form of physical phenomena belonging to the sea. If a length, which is the most tangible of the three, be squared, the result is an area; if cubed, a volume. L = length, L^2 = area, L^3 = volume. If we consider any mass with respect to unit volume we then are determining density, or $q=\frac{M}{L^3}=ML^{-3}$. But inversely, if we contemplate a volume with respect to unit mass, the result is termed specific volume, or $v=\frac{L^3}{M}=L^3M^{-1}$. If we divide a length by a time then it gives rise to a consideration of motion called velocity, or $c=\frac{L}{T}=LT^{-1}$; continuing to divide a velocity by a time (rate of rate of motion) is called acceleration or $a=\frac{c}{T}=\frac{L}{T^2}=LT^{-2}$. A force is that agent which gives motion to a mass. It is expressed in a measurement which considers the mass relative to its rate of change of motion—i. e., acceleration. $K=Ma$; but substituting $a=LT^{-2}$, we get $k=MLT^{-2}$. If M is

unity then we see that the force is equal to the acceleration. The force per unit mass is called the accelerating force. The most common natural force is that of gravity, and is expressed, of course, like other forces, in relation to a mass—e. g., $k = M\,g$—where g is the rate of change of motion (acceleration) of a falling body. Work is consideration of a force and length; $w = k\,L$, but substituting for k its value MLT^{-2}, we get $w = ML^2T^{-2}$. Work may also be spoken of in other forms as energy or potential—viz, the ability to do work. There is another force which enters hydrodynamics—namely, pressure—and it is defined as a force with respect to an area, or $p = \frac{k}{L^2} = ML^{-1}T^{-2}$. The pressure at any depth in the sea is equal to the weight of a column of water of unit depth h with respect to unit area, or $p = qgh$. But substituting $q = ML^{-3}$, $g = LT^{-2}$, and $h = L$, we get $p = ML^{-1}T^{-2}$.

The distribution in space of the value of the variables in the sea—viz., *gravity*, *pressure*, and *specific volume*—may be represented by a series of equiscalar surfaces. Those of gravity are known as equipotential surfaces; those of pressure are called isobaric surfaces; and those of specific volume, isosteric surfaces. The space between two successive equiscalar surfaces is called an equiscalar sheet. If we construct the equiscalar surfaces for unit differences in numerical value of the quantities in question, then we obtain unit scalar sheets. For example, the differences between equiscalar surfaces of potential corresponds to equiscalar units of work.

GRAVITY

Let us contemplate this force apart and alone with respect especially to the envelope of water which surrounds the earth. We may imagine that all the equipotential surfaces throughout an ocean's mass are level, then the surface of such a sea must also be exactly level, and a line to the center of the earth, with an attractive force to that point, called gravity, will plumb exactly perpendicular. Everywhere in such a sea gravity will exert a pull at right angles to the equiscalar surfaces, and the sea surface itself will be an example of a level equipotential plane. Such a motionless state is represented by Figure 3, (*a*), page 8. For the purposes of measuring and coordinating the accelerating force exerted by gravity in the hydrosphere, we shall endeavor to construct a series of concentric equipotential spheroid surfaces, each one separated by equipotential unit sheets. The thickness of such sheets will vary with the latitude, and in our particular subject (the sea) with the depth. The fundamental basis for fixing the relative position of equipotential surfaces in the sea, rests, of course, upon the presence of an attractive force which exists between the earth and the water masses on it.

A free-falling body, regardless of time or its velocity of descent, will be continuously accelerated at the constant rate of about 10 meters per second. For the purpose of measuring forces in the sea we wish to construct a series of coordinate equipotential surfaces, not merely a linear distance apart, but separated by a difference equal to 1 unit of work. Since gravity accelerates a free falling mass about 10 meters, it performs a unit amount of work, not in 10 meters, or even 1 meter, but in one-tenth of a meter, and this unit is recognized as the unit distance fixing equipotential gravity surfaces, always measured along the plumb. A unit of work, therefore, is definitely fixed and unalterable, it being, in the meter-ton-second system of units, the amount of work equivalent to raising 1 ton vertically $\frac{1}{g}$, or about one-tenth of a meter.

The unit work-length—viz, one-tenth of a meter (decimeter)—has been called by V. Bjerknes, who first used it, the dynamic decimeter; the other multiples being named dynamic meter, dynamic centimeter, etc. It is obvious that this new measure has all the equivalents of linear measure but is restricted in its use solely to the vertical. The dynamic depth of any point is not the common linear distance of this point below the surface of the sea, but it is a direct statement regarding the amount of potential or work inherent to that point relative to the sea surface.

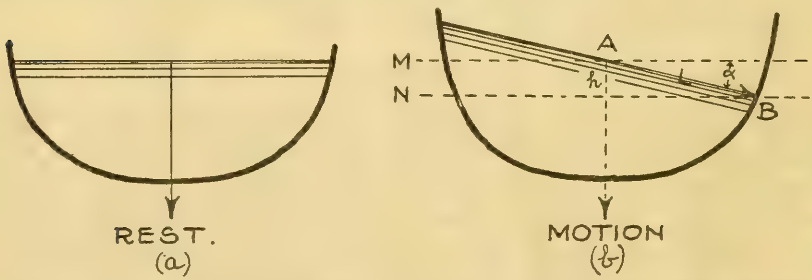

FIG. 3.—The two states of "rest" and "motion" considered with regard to the position of the sea surface. (a), "rest," all equiscalar surfaces, including the sea surface are level, and the entire force of gravity is directed as a component perpendicularly downward; (b), "motion," the equiscalar surfaces, including the sea surface, are tilted, which gives rise in such surfaces to a component of the force of gravity and causes a movement of the water particles

We have considered a motionless sea, and its equipotential surface. Suppose, on the other hand, we regard a sea surface not level; let us say, raised near the coast by a wind pressing the water masses up the inclined, continental slope. Now the sea surface being no longer level is, by definition, no longer of equal value potentially, and gravity exerts a component in the plane of the sea. Here we have the birth of a current. The size of the component force is directly proportional to the obliquity of the surface, the two conditions, "rest" and "motion," being graphically illustrated in Figure 3.

If D in Figure 3 (*b*) is the distance in dynamic decimeters between two points in the sea, and h is the unit vertical distance in common meters, then $D=g\ h$, where g is the acceleration of gravity. In (*b*), if we know the difference in dynamic depth units (the number of dynamic decimeters) between any two points, A and B in the sea, this number will be the same as the gravity potential released by a unit water mass flowing from A to B. Expressed geometrically we have from the figure, two points A and B between two level surfaces M and N, the two latter of which are h decimeters apart. The angle between line L and the planes M and N is called α

$$w=L \sin \alpha\ \bar{g}=h\ \bar{g}=D.$$

where $D=$ difference between M and N in dynamic decimeters, and α is so small in all cases that sin α may be put equal to α.

Let us, before passing on to a discussion of pressure, glance at the more exact values of acceleration due to gravity at various points on the earth, and also determine the corresponding values of potential expressed in dynamic measure. The attractive force of the earth, g, increases both with the latitude and with the depth in the sea, therefore the distances between equipotential unit surfaces—i. e., the dynamic decimeters—will be longer at the equator and near the surface of the sea, where g is comparatively small, than at the pole and near the bottom where g is comparatively large. In the meter-ton-second system of units a free falling body will accelerate approximately 9.8 meters in one second, therefore the dynamic decimeter, or unit of gravity potential, will be equal numerically to the reciprocal of this value, or 1.02 common decimeters. Stated inversely one common decimeter equals 0.98 dynamic decimeters. Simply multiplying units by 10 give results in terms of ordinary meters and dynamic meters, both of which are of a magnitude most convenient for practical investigations in hydrodynamics.

PRESSURE

Pressure is defined as a force, the intensity of which may be represented at any depth by the weight of a column of water of unit area extended vertically upwards to the surface. The force of pressure, though present at every point in the ocean, does not actually manifest itself as an active agent until we extend our consideration to two points and the difference of pressure arising. This statement, of course, holds true more or less for all forces, but it seems worth remarking here, as sea pressure, to most people, is an effect difficult to comprehend; yet a difference in pressure, such as exists when a hollow sphere is submerged in the sea, immediately becomes tangible.

Let us take, for example, the motionless ocean in which we constructed a system of equipotential surfaces 1 dynamic decimeter

apart (about one-tenth of a meter) and calculate the pressure per unit area on such a plane at a depth of about 1 decimeter. The pressure of the atmosphere being subject to comparatively slight and compensating variations can be totally disregarded throughout hydrodynamic works. (See p. 45.) We have given by definition values of pressure = weight per unit area =

$$\frac{\text{area, height, density, acceleration of gravity.}}{\text{area}}$$

Since the area values cancel, we have

$$\text{pressure} = h\ g\ \bar{q}.$$

But it has been determined that $g\ h = D$, where D equals 1 dynamic decimeter.
Substituting:

$$p = \bar{q}\ D$$

Now it remains to find a suitable system of units of pressure based upon the value equal to a water column 1 dynamic decimeter high and possessing a mean density q.

The most common example of natural pressure with which we are familiar is that of the atmosphere. It has been a practice, long established, to balance the perpendicular column of the atmospheric envelope against an equal cross-sectional area of mercury. This is a well-known experiment of any physics laboratory in which mercury has come to be adopted because of its great density; other liquids being forced to too great a height by the balance. We employ exactly the same equation, of course, as evolved in the case of a motionless ocean; in fact, we might imagine finding the pressure at various depths in the sea, theoretically, by means of a balanced column of mercury.

It has been found that at 0° C. and 45° latitude at sea level, the normal height to which mercury is forced by the ever pressing air envelope, is 0.76 meters, sometimes termed an "atmosphere." Since the acceleration of gravity at 45° latitude is known, viz, 9.8 meters, and the density of mercury at 0° C. is 13.59, let us calculate the pressure p in meter-ton-second units—i. e., the system upon which previous dynamic figures have been based. Substituting in

$p = q\ g\ h$, we have $p = 13.59 \times 9.8 \times 0.76 = 101.218.$

V. Bjerknes has used this quantity of 101.218 as a guide in deciding upon the value ascribable to p. He has selected as a unit suitable for hydrodynamic computations, the nearest integral number of 10 to 101.218, viz, 100, and has called this a bar. A bar is approximately the pressure exerted by a column of water 10 meters in height; therefore the pressure of 1 meter of water is very nearly equal to the

pressure of 1 decibar. We should note the coincidence that 1 meter below the surface the gravity potential is very nearly 1 dynamic meter less, and the pressure 1 decibar more.

$p = \bar{q}\,D$ . . . . in terms of decibar units .... (a)

$D = \bar{v}\,p$ . . . . in terms of dynamic meter units .... (b)

In order to show the close coincidence existing between dynamic units and pressure units of this system for increasing depth, we may regard the various values for the three arguments, viz, common meters, dynamic meters, and decibars, as they exist in a sea of 0° C. temperature, and 35 per mille salinity.

Decibars	100	200	300	400	500	600	700	800	900	1,000	1,200	1,400	1,600	1,800	2,000
Meters	99	198	298	397	496	595	693	792	891	990	1,187	1,385	1,582	1,779	1,975
Dynamic meters	97	194	292	389	486	583	680	777	874	970	1,164	1,357	1,551	1,744	1,936

It will be seen from the foregoing that under conditions as specified there is a difference of about 1 per cent between a depth expressed in pressure decibars and that expressed in common meters. This difference becomes even smaller under natural conditions prevailing on the earth, and thus being so insignificant, when contemplating the horizontal extension of ordinary sea areas, permits us, with the same number, to express a depth either in common meters or in decibars. The difference between dynamic meters and common meters averages about 2 per cent, and between dynamic meters and decibars about 3 per cent, and these are of a magnitude that can not be disregarded.

The two foregoing equations (a) and (b), in the case of equilibrium, expresses as simply as possible the relation existing between gravity potential, pressure, and specific volume. Thus it follows that we may by (a) find the pressure in decibars at a given dynamic depth, or by (b) the dynamic depth of a certain given pressure.

We have already described the equipotential gravity surfaces and the potential sheets with a thickness of 1 dynamic meter. Now the surfaces of equal pressure are given, called isobaric surfaces, which are separated by isobaric sheets 1 decibar thick. It is seldom that we have under natural conditions a motionless water mass, and so then it will usually be found that isobaric and level surfaces intersect. In other words, an isobaric surface contains varying potentials of gravity, and a level surface, in like manner, contains many baric variations. The intersections of these two surfaces may be considered as lines of the one inscribed on the plane of the other, accordingly as we employ equation (a) or (b). If the lines of intersection are considered inscribed on the level surfaces, they are isobars, and the chart is similar to the ordinary meteorological charts

which show the distribution of pressure. But if we employ equation (b) we must represent the result as dynamic isobaths inscribed on an isobaric surface and drawn—e. g., for unit differences of 5 dynamic millimeters. Such a method of representation corresponds to that of a common topographical chart, but the contour lines on a dynamic chart instead of showing ordinary, linear heights, show levels of equal potential. A dynamic topographical chart of a certain isobaric surface is the most approved method employed in modern dynamic oceanography to map ocean currents.

APPLICATION OF DYNAMIC UNITS

The number of unit equipotential sheets found in an isobaric sheet between two different station verticals represents a certain amount of potential energy existing between the two verticals.

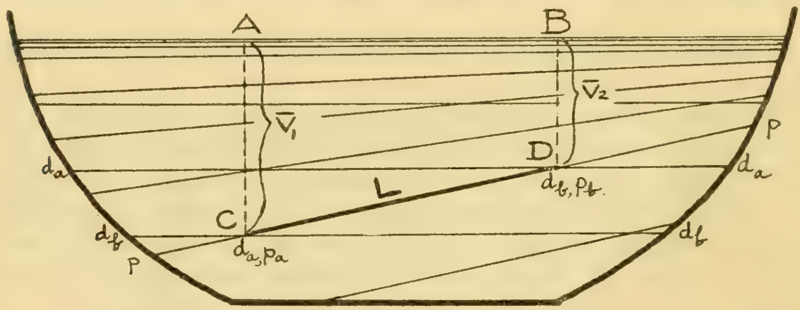

FIG. 4.—A vertical section through a sea basin and including the two stations A and B, with the respective points C and D separated by the distance L. C and D are at a depth of p decibars below the surface

Figure 4 shows a section through a sea basin which includes two stations, A and B. The horizontal lines represent the intersections with some equipotential surfaces, and the oblique lines the intersections with some isobaric surfaces. The dynamic distance from the sea surface to the isobaric surface of p decibars is d_a at station A, and d_b at station B. According to equation (b) we have:

$$d_b = p_b\ \bar{v}_b$$
$$d_a = p_a\ \bar{v}_a$$
$$\text{But } p_a = p_b$$

and therefore

$d_a - d_b = p\ (\bar{v}_a - \bar{v}_b)$ . . . . in terms of dynamic meters ---------- (c)

$d_a - d_b$ represents the difference of potential energy, due to gravity, between the points D and C in Figure 4. This energy may be converted into work, $d_a - d_b = k\ L$, where k is a force and L is the distance between the two points. Hence the force per unit mass due to gravity may be expressed

$$k = \frac{d_a - d_b}{L} = \frac{p(\bar{v}_a - \bar{v}_b)}{L}$$

DEPTH AT WHICH GREATEST OBLIQUITY OF ISOBARIC SURFACES OCCUR

It is important to distinguish where the greatest obliquity of the isobaric surfaces prevail in an ocean mass. Dynamic measurements and pressures have been considered as being laid off from the surface of the sea downwards on the assumption that the sea surface is always level—an equipotential surface. This premise demands considerable revision, as we shall see, in the light of the following facts:

As a result of compiled oceanographic observations, it is well known to-day that the greatest variations in temperature and salinity of the water take place in the upper levels of the sea. In the North Atlantic, for example, below depths of 3,000 meters there is little variation, as we proceed from place to place, in the temperature or the salinity. Now, if we regard two stations with widely differing specific volumes, we shall generally find that their difference decreases more or less rapidly with an increase in depth, and gradually approaches a constant or zero. Where the water is light we shall observe a relatively low pressure in decibars at a certain dynamic depth, or conversely at a given observed pressure in decibars, the dynamic depth will be least where the water is heaviest. In view of this natural state of the ocean, if the sea surface be level, then the obliquity of the isobaric surfaces must increase downwards and the maximum of forces and currents would be relegated to the greater depths, a condition which we know is contrary to fact. It follows alternatively that at an *appreciable* depth below the surface there will generally be a sheet where motion most nearly approaches zero and where isobaric, isosteric, and equipotential surfaces are parallel. It follows, furthermore, that above such a motionless plane, the water, over any given horizontal extent, lies at the greatest height (the surface of the sea highest) at that place where the water is the lightest—i. e., the specific volume the greatest.

We should endeavor to select from a group of observations indicative of a surveyed area an isobaric surface which in itself has the most nearly equal dynamic depths, thereby sounding out a level or motionless plane and which as stated before generally will be found to lie at a relatively great depth beneath the surface of the sea. When employed as a "bench mark" this surface provides a means of measuring the currents which usually are present in the upper levels. The velocities are determined by a comparison of any two dynamic heights measured upwards from the level, isobaric plane to the surface of the sea. Figure 5, page 14, shows in exaggerated form the obliquity of the sea surface, and also the other isobaric surfaces of observation as they lay May 5–7, 1922, south of the Grand Banks, between stations 206 and 201. The state of relative obliquity is based upon the assumption that the maximum depth of observation, the 750 decibar

surface, was a level plane. Other observations in this locality indicate that the 750 isobaric plane, however, is not always level, but a motionless state probably lies at some greater depth. The depth of 750 decibars, nevertheless, approaches most nearly to the level where absence of motion may prevail of any depth of which the International Ice Patrol records; therefore, it has been employed in this paper as an illustration of the most accurate base upon which to calculate surface currents in the vicinity of the Grand Banks.

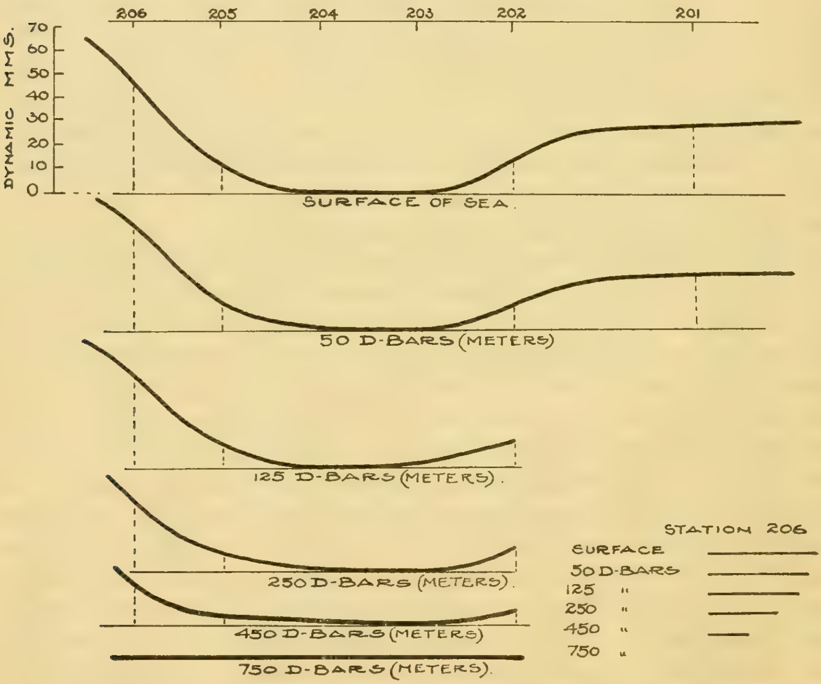

FIG. 5.—The decrease in obliquity of observed isobaric surfaces with the observed increase in depth and based upon the assumption that the depth of 750 decibars was a level plane in which no motion prevailed. The figure includes a line of stations, 206 to 201, taken by the International Ice Patrol south of Newfoundland May 5–7, 1922

The position of a level surface depends solely on the acceleration of gravity. Also, it has been pointed out that the depth to an isobaric surface depends not only upon gravity, but upon the specific volume of the overlying masses. Since we have already discussed gravity, let us now turn to the remaining term, specific volume.

SPECIFIC VOLUME

Pressure per unit area depends upon two variables, gravity and specific volume, but gravity being a more or less constant force, the agency which exerts the greatest influence to vary the pressure throughout the sea is specific volume. Specific volume has been defined as the volume of unit mass of any body. It is simply the

reciprocal of the specific gravity and is chosen in preference to the density because its value leads to the simplest method of dynamic calculations. It is, in such cases, combined directly with other parts of the term pressure, and furnishes a result in terms of gravity potential. (See equation (b), p. 11.)

In the depths of the sea observations are not made directly of specific volume, but it is obtained only after first finding the temperature, salinity, or density at a given temperature, and then correcting for the particular depth below the surface at which the observation was made. The temperature is, of course, a direct instrumental observation. The salinity is calculated ordinarily by determining the chlorine content of the sample and substituting in Knudsen's formula:

$$s = 0.30 + 1.805\ Cl$$

The two foregoing characters of sea water have been tabulated by Knudsen with regard to corresponding values of density, within the range of that normally met in the oceans.

It is vitally necessary in the course of dynamic computations, moreover, to know the specific volume in situ—that is, the actual specific volume as it existed at the particular depth at which it was found. Thus, after the specific volume has been determined from the temperature and salinity, it must be corrected for a third variable, viz, compression. It is easy to appreciate that a mass, even such as water, becomes more and more compressed the deeper down we penetrate beneath the surface. Naturally, the more compressed a body becomes, the denser it grows—i. e., its specific volume becomes increasingly less. The compressibility of sea water is not entirely dependent upon the depth below the surface, but it is also influenced by the temperature (and to a much slighter degree by the salinity) prevailing in the water itself. Generally speaking, the warmer and saltier is a water mass, the less it can be compressed. Investigations have been made regarding the compressibility of sea water at various depths under different combinations of temperature and salinity by Ekman. (cf. Die Zusammendrüeckbarkeit des Meerwassers, etc. Pub. de Constance, Copenhagen, 1908.

In order to construct tables for specific volume in situ, it is necessary to combine the two previous tables—namely, those of Knudsen for temperature and salinity with those of Ekman for compressibility. It is impossible, however, to arrange one convenient and accurate table for specific volume in situ, because of the multitudinous combinations arising between the three variables, viz, temperature, salinity, and compression, as they commonly range in the sea. Direct tablulation, according to V. Bjerknes, would require something like 256,000 pages of 500 numbers each, if intervals of 0.1 degree temperature, 0.01 per mille salinity, and 10 decibars pressure were em-

ployed as arguments. Helland-Hansen and Sandstrom in "Report on the Norwegian Fishery Investigations, Volume II, No. 4, Bergen, 1903," first provided a way to avoid such a ponderous, unwieldly work by calculating, as an initial step, the values of specific volume at frequent depths, and covering the normal range of change in compressibility in an ocean of 0° C., and a salinity of 35 per mille. A correction called the anomaly of specific volume is then added to this first figure, representing the specific volume of any charactered water, but under a similar pressure. According to these arrangements all corrections are embodied in a total of four small handy tables. The details of this ingenious method of tabulation are also described in Bjerknes', "Dynamic Meteorology and Hydrography," Carnegie Institution Publications, 1910–11. Later table groupings have been made and published by Hesselberg and Sverdrup, "Beitrag zur Berechnung der Druckund Massenverteilung im Meere," Bergens Museums Aarbok, 1914–15.

GIVEN TEMPERATURE AND SALINITY—A GRAPHIC METHOD TO FIND DENSITY

The specific volume in situ, as determined by the foregoing tables, is based upon an initial given density, usually found by means of Knudsen's Hydrographical Tables with addendum. There is considerable labor attached to interpolating when there are perhaps several hundred observational records of temperature and salinity which require conversion into density form. The Geo-Physical Institute, Bergen, where the writer spent some time, finds it convenient to facilitate such work by the construction of a graph based upon the three arguments of temperature, salinity, and density, within the range which prevails for the first two in the temperate zones. The method possesses such great advantages over the use of the tables that it is set forth here for the benefit of future investigators who may have to deal with a large number of field observations.

The construction of the graph is based upon the three formulæ of Knudsen:

(1) $s = 0.30 + 1.805\ Cl.$

(2) $\delta_o = -0.069 + 1.4708\ Cl - 0.001570\ Cl^2 + 0.0000398\ Cl^3.$

(3) $\delta_t = \Sigma_t + (\delta_o + 0.1324)\ [1 - A_t + B_t\ (\delta_o - 0.1324)].$

(For d_o, d_t, Σ_t, A_t, and B_t see Martin Knudsen's, "Hydrographical Tables," Copenhagen, 1901.) Density values are plotted as abcissæ, salinity values as ordinates, and isotherm curves, determined in accordance with the fixed relation existing between the three variables, run diagonally across the graph. In order to determine the latter with a sufficient degree of accuracy, it is necessary to fix definitely a

certain minimum number of points, by substituting values in the three given equations. As a first step let us substitute a value of *Cl.* in the first equation, which will result in the lowest value in the range of salinities which it is desired to span. A few trials indicate that a value of *Cl.* equal to 17.5 gives a desirable value of *s* equal to 31.618 per mille, which in turn is substituted in equation (2) furnishing the numeral 25.4025 as the value of δ_0. This again is substituted in equation (3) along with the values for A_t, B_t, and Σ_t for every two degrees change in the range of temperature known to prevail in the particular region which is under investigation. Thus we obtain a series of values for a salinity of 31.618 per mille, and in the same manner, another series of temperature points on the graph using other values of salinity, as shown in Table I:

TABLE I

	Cl	s_1	δ_0	$\delta_0 - 1324$	$\delta_0 + 1324$
a	17.5000	31.618	25.4025	25.2701	25.5349
b	18.000	32.520	26.1267	25.9943	26.2591
c	18.700	33.783	27.1462	27.0138	27.2786
d	19 287	34.843	28.0000		
e	19.928	36.000	28.9310	28.7990	29.0638
f	20.482	37.000	29.7390	26.6069	28.8717

The values as tabulated in Table I, upon further substitution, result in the following values as given in Table II:

TABLE II

Temperature (degrees) 2	Densities 3					
	a	b	c	d	e	f
−2	25.458	26.190	27.216	28.076		
0	25.402	26.127	27.146	28.000		
2	25.290	26.008	27.020	27.868		
4	25.124	25.836	26.842	27.863		
6	24.907	25.616	26.614	27.450		
8	24.644	25.348	26.340	27.171		
10	24.337	25.037	26.023	26.849		
12	23.987	24.685	25.665	26.486		
14	23.600	24.292	25.267	26.084		
16	23.173	23.862	24.833	25.646		
18	22.709	23.395	24.362	25.171		
20			23.856	24.662		
21					25.272	26.034
22				24.119	24.995	25.755
23					24.710	25.469
24				23.544	24.417	25.175
25					24.116	24.872

Having determined arguments 1, 2, and 3, we are now provided with data sufficient to fix the construction of a graph which in turn furnishes a rapid means of obtaining density values from given temperatures and salinities.

TABLES FOR CONVERTING DENSITIES INTO SPECIFIC VOLUMES IN SITU

In order to obtain values of specific volume in situ, Hesselberg and Sverdrup have arrived at the following formula:

$$V_{s,\,t,\,p} = 1 - \frac{\delta_t \,.10^{-3}}{1 + \delta_t \,.10^{-3}} + \delta_p + \delta_{s,\,p} + \delta_{t,\,p}.$$

where δ_t = density; δ_p = density correction for pressures; $\delta_{s,\,p}$ = correction for salinity under various pressures; $\delta_{t,\,p}$ = correction for temperature under various pressures; $V_{s,\,t,\,p}$ = specific volume in situ. These four arguments have been arranged in an equal number of tables by Hesselberg and Sverdrup, "Beitrag zur Berechnung der Druckund Masserverteilung im Meere." Bergens Museums Aarbok, 1914–15, Nr. 4. The first table representing the value $10^5 . \frac{\delta_t \,.10^{-3}}{1 + \delta_t \,.10^{-3}}$, is reprinted herewith, and the three tables for the last three terms have been combined in one table (Table IV), which makes reference much easier and without sacrifice of the requirements of practicality. When employing Tables III and IV in the method of computations as followed on page 32 it is well to note that the values as carried in Table III are from the nature of the equation (shown at the head of this page) of a negative character. In Table IV the corrections for the three factors, viz, pressure, salinity, and temperature, as they affect the specific volume in situ, are combined in accordance with signs as indicated at the head of Table IV. An example of the application of Tables III and IV is given in the computations for two oceanographic stations, 205 and 206, page 28.

TABLE III

$$10^5 . \frac{\delta_t \,.10^{-3}}{1 + \delta_t \,.10^{-3}}$$

δ_t	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
24	2344	2353	2363	2372	2387	2391	2401	2410	2420	2430
25	2439	2449	2458	2468	2477	2487	2496	2506	2515	2525
26	2534	2544	2553	2563	2572	2582	2591	2601	2610	2620
27	2629	2638	2648	2657	2667	2676	2686	2695	2705	2714
28	2724	2733	2743	2752	2762	2771	2780	2790	2800	2809

TABLE IV

–		–		+																					
D	Σ_D	−2°	−1°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	32	33	34	36
0	0	0	0	0																	0				
10	5																				0				
15	7																				0				
20	9																			0	1				
25	11																			0	1				
30	14																		0	1	1				
35	16																	0	1	1	1				
40	19														0	0	1	1	1	1	1				
45	21	0										0	1	1	1	1	1	1	1	1	1				
50	23	1						0	1	1	1	1	1	1	1	1	1	1	1	1	1				
55	25	1						0	1	1	1	1	1	1	1	1	1	1	1	1	1				
60	27	1					0	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
65	29	1					0	1	1	1	1	1	1	1	1	1	1	1	1	1	2				
70	31	1				0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2				
75	34	1				0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2				
80	36	1			0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2				
85	38	1			0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3				
90	40	1			0	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3				
100	45	1			1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3				
125	56	1	0	0	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4	4				
150	68	1	0	0	1	1	1	2	2	2	3	3	3	3	3	4	4	4	4	5	5	−1	−1	0	0
200	90	1	1	1	1	1	2	2	3	3	4	4	4	5	5	5	5	6	6	6	6	−1	−1	0	0
250	112	1	1	1	1	1	2	3	3	4	4	5	5	6	6	6	7	7	7	8	8	−1	−1	0	0
300	135	2	1	1	2	2	3	4	4	5	5	6	7	7	8	8	8	9	9	9	9	−1	−1	0	0
350	157	2	1	1	2	2	3	4	5	5	6	7	8	8	9	9	10	10	11	11	11	−1	−1	0	0
400	180	2	1	1	2	3	4	5	6	6	7	8	9	9	10	11	11	12	12	13	13	−2	−1	−1	+1
450	202	2	1	1	3	3	4	5	6	7	8	9	10	10	11	12	13	13				−2	−1	−1	+1
500	225	3	1	1	3	4	5	6	7	8	9	10	11	12	13	14	14	15				−2	−2	−1	+1
600	269	3	2	2	3	5	6	7	8	10	11	12	13	14	15	15	16	17				−3	−2	−1	+1
700	313	4	2	2	4	5	7	8	10	11	13	14	15	16	17	18	19	20				−3	−2	−1	+1
750	336	4	2	2	4	5	7	9	10	12	13	15	16	17	18	19	20	21				−3	−2	−1	+1
800	358	4	2	2	4	6	8	10	11	13	14	16	17	18	19	20	21	23				−4	−2	−1	+1
900	402	5	2	2	5	7	9	11	13	14	16	18	19	20	22	23	24	26				−4	−3	−1	+1
1,000	446	6	3	3	5	7	10	12	14	16	18	20	21	22	23	25	27	29				−5	−3	−1	+1
1,100	491	6	3	3	6	8	11	13	16	17	19	21	23	24	25	27	29	31				−5	−3	−1	+1
1,200	533	7	3	3	6	9	12	14	17	19	21	23	25	26	28	30	32	34				−5	−4	−2	+2
1,400	620	8	4	4	7	10	13	16	19	22	25	27	29	31	33	35	37	40				−6	−4	−2	+2
1,600	706	9	4	4	8	12	15	19	22	25	28	31	33	35	37	39	42	45				−7	−5	−2	+2
1,800	791	10	5	5	9	13	17	21	24	28	31	34	37									−8	−5	−3	+3
2,000	876	11	5	5	10	14	19	23	27	31	34	38	41									−9	−6	−3	+3

DISTRIBUTION OF MASS

Information as to the distribution of mass in a free-moving media, such as in an ocean, furnishes a direct insight of the dynamic conditions there. Representation of mass distribution is clearly shown by isosteric lines, which in profile form, after all corrections have been made, including that of compressibility, is called a dynamic section. An example of such is to be seen in Figure 12, page 30, which has been constructed from a group of stations taken by the International Ice Patrol, 1922, and extended in a line across two currents in the ice regions south of Newfoundland.

The importance of the position of isosteric surfaces as an indicator of the motions taking place in a water mass, was pointed out in a previous paragraph. Enlargement of this exposition can be continued hereby regarding such a vertical section where a system of isobaric and isosteric surfaces, by intersection with the vertical plane, divide the latter into a set of parallelograms. If we extend the vision to three dimensions, then the parallelograms take form as a set of tubes.

Since they lie between adjacent isobaric surfaces their continuation must cease only by turning on themselves or by meeting the sides of the basin. V. Bjerknes has given the name "solenoid" to an isobaric-isosteric tube. It is convenient to select as a unit tube one included by isosteric surfaces constructed for intervals of 10^{-5} of specific volume, and isobaric surfaces constructed for intervals of one centibar. Bjerknes has also called attention to the significance of solenoids by stating that the measure of the intensity of forces in a given vertical sectional area is in direct proportion to the number of solenoids running through it. This number depends upon the degree of stability and inclination; the greater the stability and the inclination, the greater the number of solenoids per unit cross-sectional area.

EFFECT OF EARTH ROTATION ON OCEAN CURRENTS

Dynamic tendencies of water particles have been discussed purely as indicated by mass distribution; now the behavior of such phenomena are traced in the form of actual motion on, and as qualified by, the veering surface of a rotating sphere.

In order to understand the effect of earth rotation on currents, we might begin by studying very closely the absolute movement of a fixed body at the pole of a rotating sphere and another similar body on the equator. It will soon be perceived that the former enjoys a pure centric movement while the latter has a pure translatory motion, and any intervening point partakes a centric-translatory path. Bodies at rest relatively to the globe, as also the surface of the earth itself, are, strictly speaking, under a phase of centric and translatory motion, the relation between the two depending upon the geographical latitude. This phenomenon is very difficult to comprehend, since all of our senses are trained to accept the earth and resting bodies as a stationary base, and these remarks in so short a space, can hope to touch generalities only. Those who are interested in a detailed exposition of the subject are referred to Krummel (cf., Handbuch der Ozeanographie, vol. 2). Also Humphreys (cf., "Physics of the Air." 1920).

As long as all bodies remained in fixed relations, a state of "rest" may be said to prevail, by virtue of the fact that no variations from the relative positions exist. But distinction immediately arises whenever any free motion whatsoever, relatively to the earth, is introduced. At any other point on the earth's surface than along the equator, due to the element of centricity previously described, divergence takes place between the straight path of a particle due solely to inertia, and the movement of other particles held fast to the surface of the earth and carried around with it as it rotates. This fact was proven years ago when the straight line of motion possessed by Focault's pendulum swinging to and fro soon revealed

that the surface of the earth was veering to the left in the Northern Hemisphere. It is more natural to regard the inverse perspective—that is, the earth and resting bodies as stationary—then the paths of inertia are apparently being continuously deflected to the right. Earth rotation exerts no effect on a water mass free from circulation relatively to the earth, but on the other hand no true conception of free-moving currents can be had unless this great influence is considered. In this connection it should be realized, from the foregoing remarks on motion on a rotating sphere, that currents can not be traced solely to a provocative force at their source, but they are only to be observed as a resultant of a force, the effect of which is constantly being deformed by the earth "sliding" beneath it. If a water particle moves solely due to inertia, without being acted upon by any force, it will follow a course "cum sole" (clockwise with the sun). As the latitude increases the tendency which drives a water particle to the right of its course becomes more and more intensified, and the faster it moves, the greater becomes the quasi force tending to deflect it.

In order to study this quasi force in detail, it is convenient, similar to the procedure employed in the investigation of varying mass and pressure (see fig. 4, p. 12) to regard the circulation of the curve in a plane between any two verticals. We may take, for example, stations A and B (fig. 6, p. 22), with their verticals AC and BD forming the plane ABDC. The development of an equation for expressing the rotation effect demands too great a digression into mathematics and is not warranted here, but it has been evolved by V. Bjerknes as equal to

$$2\omega \frac{ds}{dt}$$

where ω represents the angular velocity of the earth, viz, 0.0000729; and is the projection of the closed curve of the circulation, as illustrated here by the rectangle ABDC, on the equatorial plane; and $\frac{ds}{dt}$ represents the rate of change of the projection on the plane of the equator.

In Figure 6, page 22, if the curve of circulation ABDC, which is being investigated, is projcted upon the equatorial plane, it is evident that a change of the proportional area is effected only by components normal to the plane and not by those tangential to it. Also the vertical movements can be considered negligible, since they are insignificant as compared with horizontal magnitudes. Helland-Hansen and Sandstrom have, by this means, found the value for Bjerknes' equation in terms of the projection on the plane of the sea surface

$$\frac{ds}{dt} = \frac{d\sigma}{dt} \sin \phi$$

where σ is the projection on the sea surface, and ϕ is the geographical latitude. Substituting this new value for $\frac{ds}{dt}$ we have

$$2\omega \frac{d\sigma}{dt} \sin \phi \text{ .... (d)}$$

$$\text{but } \frac{d\sigma}{dt} = A'B'D''C'' = (c_0 - c_1), L \text{ where}$$

c_0 = velocity per second in a given horizontal plane.
c_1 = velocity per second in another horizontal plane.
L = distance between stations.

Substituting in (d) for the new value $\frac{d\sigma}{dt}$ we have

$$2\omega \sin \phi \ (c_0 - c_1) L \text{ .... (e)}$$

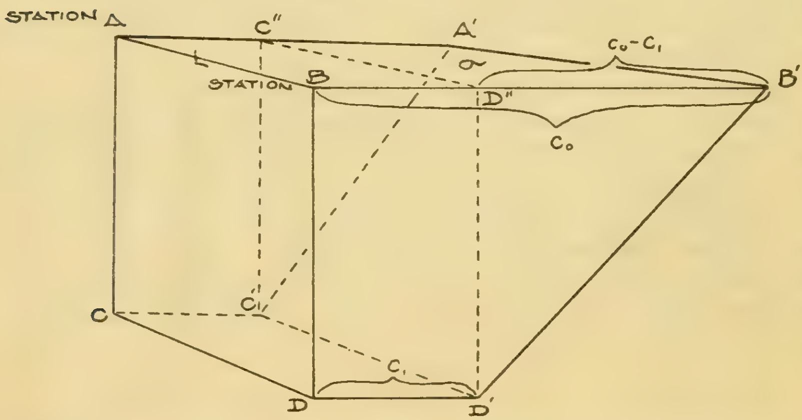

FIG. 6.—Lines AA′ and BB′ represent the velocity of the surface current, or c_0, per unit T; CC′ and DD′ indicate the velocity of the current at a greater depth, or c_1. The difference in the velocity of the two movements is equal to D″ B′, or $c_0 - c_1$. The movement is assumed to be normal to the vertical plane ABDC, which is passed through the two stations A and B. Area C″ D″ B′ A′, indicated by the symbol σ, represents the difference in the change of areas per change of T, projected on the sea surface and developed by the progression of the two lines AB and CD with the respective velocities c_0 and c_1

Thus by (e) we are furnished with an expression for the effect of terrestial rotation in terms of the latitude; the distance between stations; and the difference in velocity of the current between any two levels. It is easy to see that if we are able to find some point along the verticals where zero velocity prevails, then we have a means of expressing the real velocity. It is customary to extend the investigations to depths where it is believed motionless water lies, and then $c_1 = 0$, and c_0 is the true velocity on the surface. (See p. 13 regarding the obliquity of isobaric surfaces.)

RESOLUTION OF FORCES IN GRADIENT CURRENTS

It has been pointed out in the previous section that the effect of rotation tended to deflect currents to the right in the Northern Hemisphere. This quasi force can be represented by a vector of a certain magnitude which lies 90° to the right of the current. If we let the line AB, Figure 7, represent a more or less steady current of sufficient size to give the water particles a translatory path, then the effect of terrestial rotation may be shown by the line AC, Figure 7. Since the rotation effect is always present, as represented by the line AC, it follows that the only condition under which a current can flow, stream, and be preserved, is fulfilled by a force or system of forces (when friction is disregarded) which acts equal and opposite to AC, and is represented in Figure 7 as the line AE. AE illustrates the force characterized as due to varying mass and pressure, and is measured by the equated values of the three variables—*gravity*, *pressure*, and *specific volume*. It is, moreover, the impelling force of such gradient currents (i. e., currents resulting from an obliquity of equiscalar surfaces); and it should be remarked here that this driving force is to be sought not back along the current's course to a river-like source, but it always lies on the right hand stretching along the entire extent of flow. The Gulf Stream, for example, as it follows a general path around the periphery of the North Atlantic basin, is energized along the shores of Europe (a fact which is just as vital for its propagation) as well as receiving propulsion in the Caribbean. Where the velocity is relatively great, there the dynamic gradient is correspondingly steep, and without such energy distributed around Atlantic slopes, the Gulf Stream would directly disintegrate. If we divide gradient currents into the forces which combine to give flow to the water particles we have (1) dynamic inequalities due to varying densities, and (2) the effect of earth rotation, each one of which acts in a plane perpendicular to the path of the moving water particles. Since (1) and 2) lie in the same plane, and inasmuch as the acceleration of the closed curve ABDC (see fig. 6, p. 22) (represented by the line AC, fig. 7) has been determined, let us now regard the rectangle ABDC with respect to acceleration tending in the opposite direction. (Shown as line AE, fig. 7.)

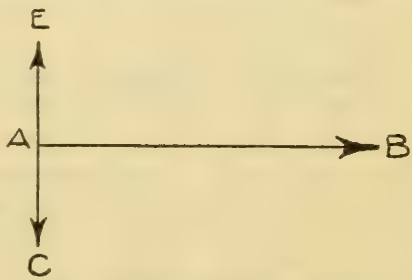

Fig. 7.—A diagrammatic front view showing the relative positions of the major elements belonging to a steady gradient current. AB represents the path of flow of the water particles; AE, the position of the forces due to Archimedean tendencies which impel the current; and AC the position of the quasiforce of earth rotation in a plane 90° to the right (in the northern hemisphere) of the direction of the current

It will be recalled that the force of varying mass and pressure tending to produce acceleration by equation (b) is equal to

$$D = p\,\bar{v}$$

and the accelerating force in a closed curve ABDC between stations A and B, in the plane formed by the verticals AC and BD, is equal to

$$d_a - d_b = p\ (\bar{v}_a - \bar{v}_b).$$

Since AC equals AE, (fig. 7, p. 23), we may substitute (e) and obtain the following:

$$d_a - d_b = p\ (\bar{v}_a - \bar{v}_b) = 2\ \omega \sin \phi\ (c_0 - c_1) L \text{-----------} \quad \text{(f)}$$

Thus finally we are furnished with an expression which includes the forces due to the distribution of mass and pressure tending to accelerate a current moving on a rotating earth, and moreover, it is formed of terms which readily lend themselves to the requirements of practical oceanography.

THE PRACTICAL METHODS AND FORM OF COMPUTATIONS GENERALLY FOLLOWED IN DYNAMIC PHYSICAL OCEANOGRAPHY

We may now continue by describing the manner in which the unknown terms of (f) are determined by observational data secured from a closed curve ABDC in a plane formed by verticals AC and BD, between stations A and B. First we shall regard the forces tending to

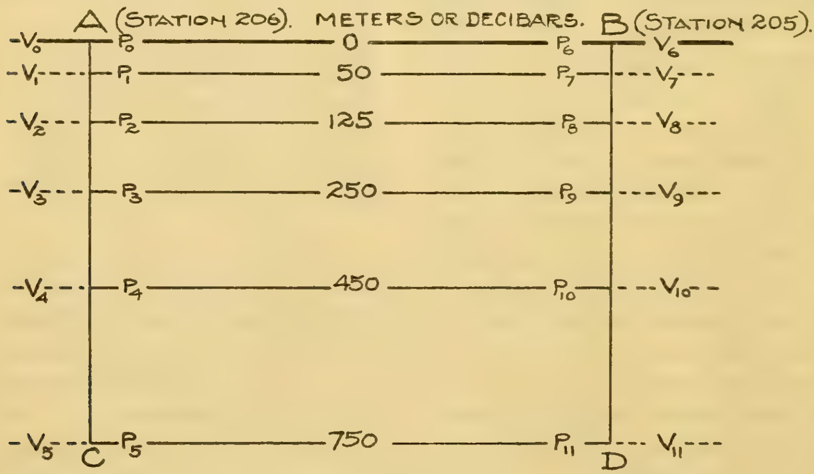

FIG. 8.—Two verticals A and B at stations 206 and 205, respectively, and with the observed values of v and p at depths expressed in decibars or meters as follows: 0, 50, 125, 250, 450, and 750

accelerate the particles as a result of varying degrees of stability in the water columns of any given area. The abstract exposition, furthermore, has been supplemented by a practical example wherein stations A and B are replaced by stations 206 and 205, respectively. (See computations, p. 28.) These stations were taken by the International Ice Patrol in 1922, the sectional line forming approximately a right angle with the northern edge of the Gulf Stream south of the Grand Banks.

It is assumed that the specific volumes in situ have been calculated from the tables, as based upon the temperature and salinity records from the observed depths, viz, 0, 50, 125, 250, 450, and 750 meters. The values of p are, for all practical purposes, equal to the depth in meters—that is, at a depth of 750 meters the pressure is 750 decibars (see p. 11). In order to compute as accurately as possible the value of D (the dynamic depth) for the vertical AC, it is necessary to consider the change at frequent depths which occurs in the value of v (the specific volume). In order to comprehend the method of mathematical computation customarily followed, e. g., p. 28, it will be helpful to regard Figure 9.

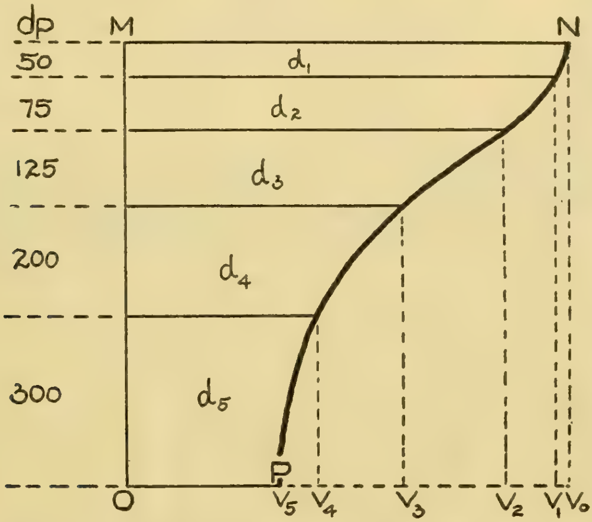

FIG. 9.—A graphic means of illustrating the mathematical integration customarily employed in computing the dynamic depth to a given observed pressure beneath the sea surface

The area MNPO (assumed equal numerically to D_a) is formed partly by the curve NP, which represents varying values of v, and the side MO, which indicates the scale of pressure. The value of D_a, therefore, represented by the area MNPO is equal in value to the sum of all the smaller areas d_1, d_2, d_3, d_4, and d_5. The area d_1 (and the values of all the other small rectangles in similar manner) may, with sufficient accuracy, be put equal to

$$d_1 = \left(\frac{v_0 + v_1}{2}\right) dp_1$$

or

$$D_a = \left(\frac{v_0+v_1}{2}\right)dp_1 + \left(\frac{v_1+v_2}{2}\right)dp_2 + \left(\frac{v_2+v_3}{2}\right)dp_3 + \left(\frac{v_3+v_4}{2}\right)dp_4 + \left(\frac{v_4+v_5}{2}\right)dp_5$$

which equals the value of the gravity potential, relatively to the sea surface, expressed as a depth in dynamic meters at which the pressure

of 750 decibars prevails. Other verticals are computed in a like manner and

$$D_a - D_b = \Delta D,$$

which represents the value of the force tending to produce acceleration of the water particles in the plane of the closed rectangular curve ABDC. The direction in which the force tends to act may be deter-

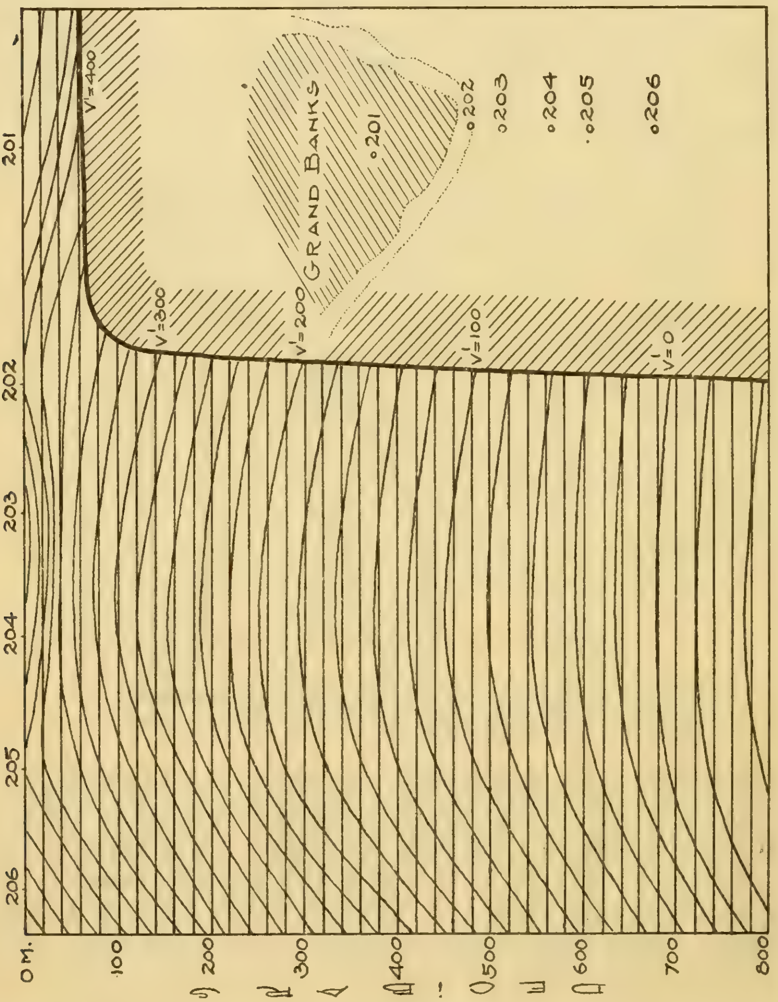

FIG. 10.—Distribution of specific volume in a section south of Newfoundland May 5-7, 1922, and also a cross-sectional view of the solenoidal tubes, each complete parallelogram of which represents the presence of 400 solenoids. Horizontal scale, 1:2,000,000; vertical scale, 1:5,000

mined by the relative values of v, the water being forced upwards most pronouncedly at that vertical where the values of v are a maximum.

It is customary and of assistance in dynamic investigation of an ocean mass to represent the distribution of specific volume, as found by actual observations, graphically in vertical projection, the pressure in decibars being shown as ordinates in the graph. Figure 10 includes a line of stations, 201 to 206, taken from the records of the International Ice Patrol, and furnishes an example of such a method of illustration.

In this particular figure the horizontal lines have been drawn for every 20 decibars. The curved lines represent lines of equal specific volume and are drawn for every 20 units in the fifth decimal place of v. In Figure 10, v^1 means $10^5\,(v-0.97000)$. Since a solenoid is formed by the intersection of isobaric surfaces with isosteric surfaces, it is not difficult to see that a vertical plane, such as illus-

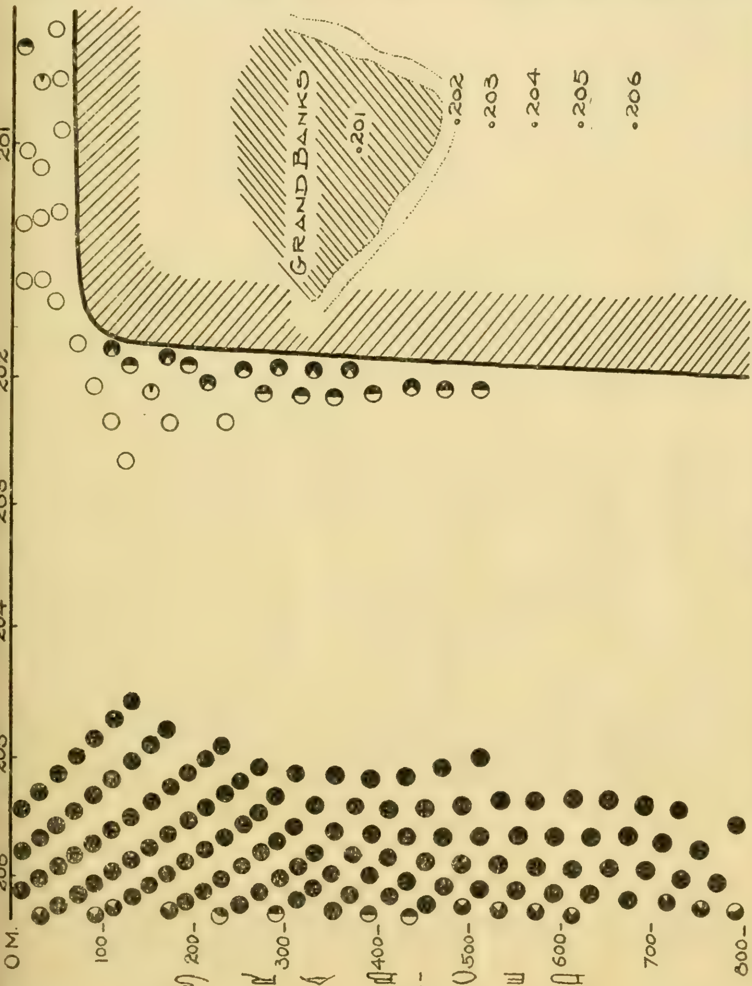

FIG. 11.—An effective illustration of the distribution of solenoids and the dynamic tendencies in a vertical section taken approximately at right angles to both the Gulf Stream and the Labrador Current south of the Grand Banks, May 5-7, 1922. Each whole dot represents 400 solenoids, which gives approximately 50,000 solenoids for the Gulf Stream as represented by the black circles, and about 12,200 solenoids for the Labrador Current as shown by the white circles. The current of the Gulf Stream is represented as flowing perpendicular to the plane of the paper toward the reader and the Labrador Current in the opposite direction. Horizontal scale, 1:2,000,000; vertical scale, 1:5,000

trated in Figure 10, page 26, will intersect the solenoidal tubes forming a number of parallelograms, each one of which indicates the presence of 400 solenoids.

The distribution of forces tending to produce acceleration in such a vertical section may be further emphasized by erasing all the isobaric-isosteric lines after the location of the centers of the parallelograms have been marked out. This method of illustration is shown in Figure 11.

Where the isosteres lie deepest and the inclination is greatest, there is indicated at that place a tendency to push the water upwards with a maximum strength, and where the isosteres lie highest, there the force is at a maximum tending to drive the water downwards. But whatever the position of the isosteres may be, it is well to bear in mind that when the section lies at right angles to the direction of the current, there is no actual movement of the water particles within the vertical plane whatsoever. The value of the solenoids lies in the fact that they express the *presence* of a force or forces tending to cause circulation around the rectangle. The Ferrelian force (effect of earth rotation) precludes *actual* movements restricted solely parallel to the current path AB, Figure 7, page 23, as previously described.

DETERMINATION OF DYNAMIC DEPTH, STATIONS 205 AND 206

We may continue to treat the Ice Patrol records of stations 201 to 206 dynamically, by computing the values of specific volume from the given station data and correcting the same to specific volume in situ; then, by means of the equation on page 25, determine the dynamic depth of the successive isobaric surfaces of observation. In order simply to illustrate the methods customarily employed, we have selected two stations only, stations 205 and 206 located on the northern edge of the Gulf Stream south of Newfoundland. Similar procedure and similar results follow, of course, in like manner from other given station data.

dp	Meter depth	t	s	d_t	Table III	Table IV	Σ_1	Mean Σ_1	$\Sigma^1{}_m-\delta p$	Σ_2	E	$(E-E_1)10^5$	$V10^5$	$(V-V_1)10^5$
							STATION 205							
	0	5.7	33.93	26.77	2607	0	2607			--------	0	0	.97393	129
50	50	12.0	35.31	26.85	2615	22	2637	2622.5	131125	131125	48.68875	.06225	.97363	121
75	125	10.1	35.16	27.07	2635	53	2688	2662.5	199687	330812	121.69188	.14676	.97312	104
125	250	6.7	35.00	27.48	2674	109	2783	2735.5	341938	672750	243.27250	.25251	.97217	65
200	450	5.4	35.04	27.68	2694	197	2891	2837.0	567400	1240150	437.59850	.36501	.97119	47
300	750	4.6	35.01	27.75	2700	327	3027	2959.0	887700	2127850	728.72150	.50201	.96973	44
							STATION 206							
	0	18.1	36.21	26.18	2551	0	2551			--------	0	0	.97449	185
50	50	18.0	36.33	26.31	2564	22	2586	2568.5	128425	128425	48.71750	.09100	.97414	172
75	125	16.3	36.11	26.55	2587	50	3637	2611.5	195862	324287	121.75713	.21201	.97363	155
125	250	12.9	35.56	26.86	2616	106	2722	2679.5	334937	659224	243.40776	.38777	.97278	126
200	450	9.2	35.12	27.20	2648	193	2841	2781.5	556500	1215724	437.84276	.60927	.97159	97
300	750	6.6	34.95	27.46	2672	323	2995	2918.0	875400	2091524	729.08476	.86527	.97005	76
Col. 1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7	Col.8	Col.9	Col.10	Col. 11	Col. 12	Col.13	Col.14	Col.15

The abbreviations appearing at the top of the columns in the preceding compilation of computations are explained as follows:

Column 1 (dp) represents the difference of pressure in decibars of successive observed depths, which for all practical purposes is equal to the differences in depths of observation in meters.

Column 2 contains the depths at which observations were made.

Column 3 (t) contains the observed temperatures.

Column 4 (s) contains the determined salinity.

Column 5 (d_t) contains the density as found directly from the temperature and the salinity. (Contraction adopted, see p. 2.)

Column 6 (Table III) is a form of inversion table combined with other corrections (see p. 18).

Column 7 (Table IV) contains the combined corrections with due regard to signs for the three factors, pressure with depth, with temperature, and with salinity (see p. 19).

Column 8, contains the values of $(1-v)\ 10^{5}$, where v represents the specific volumes in situ.

Column 9, contains the mean values between the successive depths of observation as they appear in column 8.

Column 10, contains the product of the values as contained in column 9 and the difference of pressure in decibars as shown by column 1.

Column 11 (Σ_2) contains the results obtained by adding progressively the successive ciphers as contained in column 10. Values from columns 6 to 11, inclusive, are negative throughout.

Column 12 (E) contains the calculation of the dynamic depths of the observed isobaric surfaces. Found by combining values in column 2 with those in column 11.

Column 13 $(E-E_1)\ 10^5$ contains the anomaly of the dynamic depth of observation—i. e., it represents the difference in dynamic depth between the isobaric surface actually observed and the position of the same isobaric surface in a sea of 0.0° C. and 35 per mille salinity.

Column 14 (V) 10^5 contains the specific volume in situ, or one minus the value as contained in column 8 multiplied by 10^5.

Column 15 $(V-V_1)\ 10^5$ contains the anomaly of specific volume in situ, or, in other words, the difference in specific volume in situ as found from that at a similar depth in a sea of zero degrees Centrigrade and 35 per mille salinity. The values for the dynamic depth (D_1) and the specific volume in situ, (V_1), as found in an ocean of zero degrees Centigrade and 35 per mille salinity, are given in the following table, Table V. The selected depths recorded therein are the same as those previously carried in Table IV.

Table V*

E_1 = dynamic depth in sea 0° C., 35 per mille. V_1 = specific volume in sea 0° C., 35 per mille.

Decibars	E_1	V_1	Decibars	E_1	V_1	Decibars	E_1	V_1	Decibars	E_1	V_1
0	0	.97264	50	48.62650	.97242	125	121.54512	.97208	700	679.74949	.96951
5	4.86315	.97262	55	53.48854	.97240	150	145.84574	.97197	750	728.21949	.96929
10	9.72620	.97260	60	58.35045	.97237	200	194.43849	.97174	800	776.67849	.96907
15	14.58914	.97257	65	63.21225	.97235	250	243.01999	.97152	900	873.56349	.96863
20	19.45195	.97255	70	68.07395	.97233	300	291.59024	.97129	1000	970.40449	.96819
25	24.31465	.97253	75	72.93554	.97231	350	340.14924	.97107	1200	1163.95549	.96732
30	29.17725	.97251	80	77.79700	.97228	400	388.69699	.97084	1400	1357.33249	.96645
35	34.03974	.97249	85	82.65835	.97266	450	437.23349	.97062	1600	1550.53649	.96559
40	38.90210	.97246	90	87.51960	.97224	500	485.75899	.97040	1800	1743,56849	.96473
45	43.76435	.97244	100	97.24175	.97219	600	582.77649	.96995	2000	1936.42949	.96388

* The values shown are based upon those contained in Table 8H, Bjerknes' "Dynamic Meteorology and Hydrography," Carnegie Inst. Pub., 1910.

The isosteric lines, Figure 10, page 26, represent in vertical section, the distribution of the specific volume in situ (v). But except in regions where rapid currents prevail, the lines of equal specific volume vary little, especially in the greater depths, from either the lines of equal pressure or the lines of equal depth. This is due to the fact that the effect of the increasing pressures with the depth more than

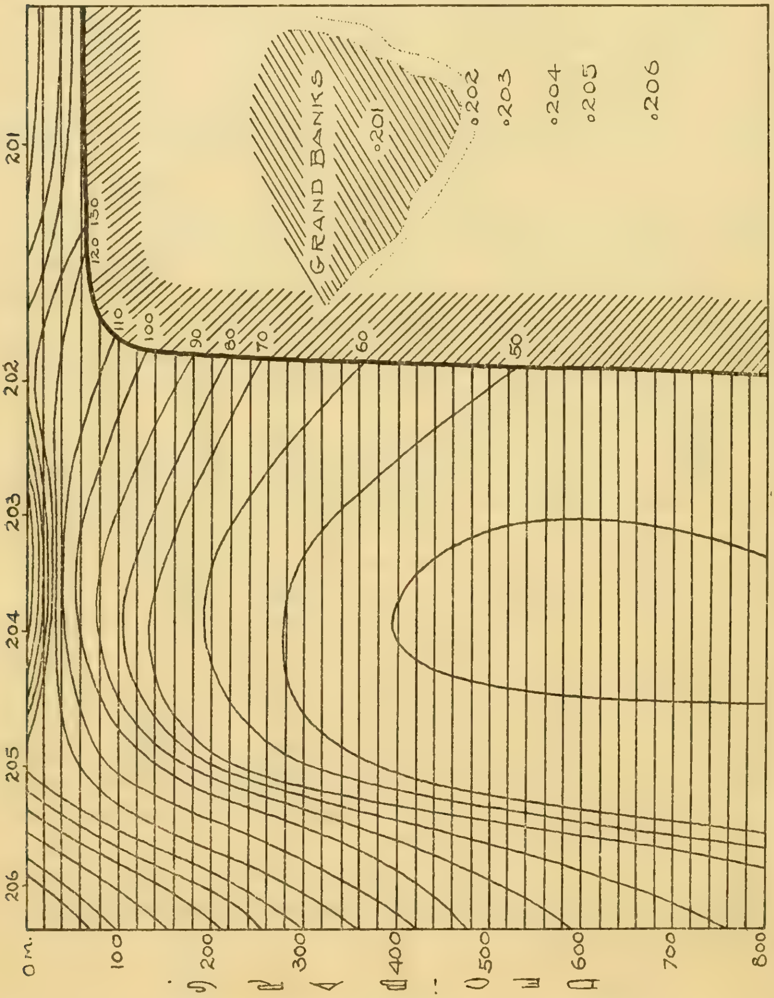

FIG. 12.—A dynamic section constructed from the values of the anomalies of specific volume $(V-V_1)\ 10^5$ at stations 206 to 201. This is an example of the most approved method of illustrating in vertical profile the dynamic conditions found prevailing in a water mass. Horizontal scale, 1: 2,000,000; vertical, 1: 5,000

offset the variations in the specific volume due purely to temperature or salinity variations. In order to secure a more striking graphic representation of the distribution of specific volume in situ, it is customary to draw the isosteres in accordance with the values of $V-V_1$ (see computations, column 15, p. 28). Although these ciphers are of a smaller numerical value than the actual specific volumes, yet they provide a greater contrast than the latter, and a section thus

drawn is the type most commonly employed for purposes of illustration. A dynamic section, Figure 12, formed by stations 201 to 206, International Ice Patrol, 1922, is shown on page 30.

VELOCITY—HOW DETERMINED

We may now return to a consideration of equation (f), page 24, in order to find the velocity of the current between stations 206 and 205, by substituting at the same time for d_a and d_b the values as found at the six levels of observation of the two foregoing stations. Since the velocity is the term desired, equation (f), page 24, may be written in the following form:

$$c_o - c_1 = \frac{(d_a - d_b)\,10^5}{2\omega \sin \phi_m L 10^5} \qquad \text{(g)}$$

where $\phi_m = 41° - 10'$, the mean latitude of stations 206 and 205. The value of 10^5. $2\omega \sin \phi$, by Table VI, page 32, is found to be equal to 9.60. The multiple 10^5 is introduced simply to bring the velocity values into centimeter-gram-second terms. L, which is the distance between stations, is equal to 32 miles, or 59 kilometers. (See Table VII, p. 33.)

Stations	Depth in dynamic meters				
	50	125	250	450	750
205	48.71750	121.75713	243.40776	437.84276	729.08476
206	48.68875	121.69188	243.27250	437.59850	728.72150
$d_a - d_b$	0.02875	0.06525	0.13526	0.24426	0.36326

If we treat the values of $d_a - d_b$ as whole numbers and divide them by the value of $2\omega \sin \phi_m L\ 10^5$, the latter of which is found equal to 569.28, we obtain the following:

	50	225	250	450	750
$C_0 - C_1$	5.0	11.5	23.8	42.9	63.6

If it is assumed that c_1 is equal to zero at a depth of 750 decibars (meters), then the following velocities are furnished at the various levels of observation, from the surface downwards. (If it is desired to express velocities in terms of knots per hour, 10 cm./sec. is equal approximately to 0.2 knots per hour.)

Meters or decibars	0	50	125	250	450	750
C_0— in cm./sec	64	59	52	40	21	0
C_0— in Kt./Hr	1.3	1.2	1.0	0.8	0.4	0

It is often desirable to express the velocities at the various levels of observation graphically in the form of a current diagram, in which case it is customary to measure the velocity units along the abcissa and the depths along the ordinate. The graphic representation of the current between stations 205 and 206 is shown by Figure 13.

Table VI is a copy of a table (Table 12), which first appeared in a contribution by Sandstrom and Helland-Hansen, in "Report on Norwegian Fishery and Marine Investigations," Volume II, No. 4, Bergen, 1903. It contains the computed values of $2\ \omega \sin \phi\ 10^5$ for each degree of latitude.

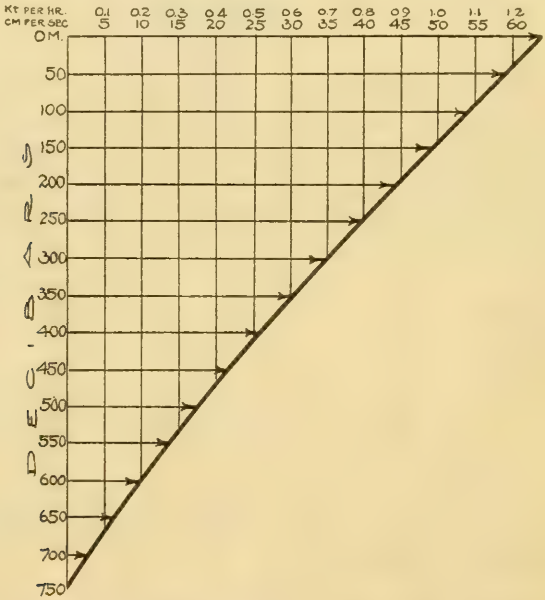

FIG. 13.—Current velocity diagram, northern edge of Gulf Stream between stations 205 and 206, May 5–7, 1922

TABLE VI

$$2\omega \sin\phi\ 10^5 = 14.58 \sin\phi$$

ϕ	0	1	2	3	4	5	6	7	8	9
0-------	0.00	00.26	00.51	00.76	01.02	01.27	01.52	01.78	02.03	02.28
10------	02.53	02.78	03.03	03.28	03.53	03.77	04.02	04.26	04.51	04.75
20------	04.99	05.23	05.46	05.70	05.93	06.16	06.39	06.62	06.85	07.07
30------	07.29	07.51	07.73	07.94	08.15	08.36	08.57	08.78	08.98	09.18
40------	09.37	09.57	09.76	09.95	10.12	10.31	10.49	10.67	10.81	11.01
50------	11.17	11.33	11.49	11.65	11.80	11.95	12.09	12.23	12.37	12.50
60------	12.63	12.75	12.87	12.99	13.11	13.22	13.32	13.42	13.52	13.61
70------	13.70	13.79	13.87	13.95	14.02	14.09	14.15	14.21	14.26	14.31
80------	14.35	14.40	14.44	14.47	14.50	14.53	14.55	14.56	14.57	14.58

Since the value of L, the distance between stations, is expressed in kilometers, a conversion table of nautical miles to kilometers is included herewith:

TABLE VII

Nautical miles	Kilometers									
	0	1	2	3	4	5	6	7	8	9
0	0.0	1.9	3.7	5.6	7.4	9.3	11.1	13.0	14.8	16.7
10	18.5	20.4	22.2	24.1	25.9	27.8	29.6	31.5	33.3	35.2
20	37.0	38.9	40.7	42.6	44.4	46.3	48.2	50.0	51.9	53.7
30	55.6	57.4	59.3	61.1	63.0	64.8	66.7	68.5	70.4	72.2
40	74.1	75.9	77.8	79.6	81.5	83.3	85.2	87.0	88.9	90.7
50	92.6	94.5	96.3	98.2	100.0	101.9	103.7	105.6	107.4	109.3
60	111.1	113.0	114.8	116.7	118.5	120.4	122.2	124.1	125.9	127.8
70	129.6	131.5	133.3	135.1	137.1	138.9	140.8	142.6	144.5	146.3
80	148.2	150.0	151.9	153.7	155.6	157.4	159.3	161.1	163.0	164.8
90	166.7	168.5	170.4	172.2	174.1	175.9	177.8	179.6	181.5	183.3
100	185.2	187.1	188.9	190.8	192.6	194.5	196.3	198.2	200.0	201.8

The velocity values as they are usually finally shown, represented by c_0, page 31, are the differences between the movement on the surface and that at a level where it is believed motionless water lies. But it is important to bear in mind that as a result of dynamic computations, the values of velocities are expressed in terms NORMAL TO THE VERTICAL SECTION which may include any two stations. Another step is necessary if it is desired to obtain the value of the real velocity. Let us assume that the direction of flow but not the rate is known. In Figure 14 suppose the direction of the current is represented by the parallel lines AM and BM_1, between the two stations A and B. Furthermore, let it be given that the velocity normal to the section has been computed by means of equation (g), page 31, and that it is given on the figure as the line K. We now wish to determine the true velocity, V, which lies in a direction parallel to the lines AM and BM_1, and which forms the angle a with the computed velocity. The value of V, it is easy to see from the figure, is equal to $\frac{K}{\cos a}$. The same results may be obtained graphically by laying off the angle a and dropping a perpendicular from the end point of the known side K upon the unknown side V, and then measuring the length of the latter in units the same as K.

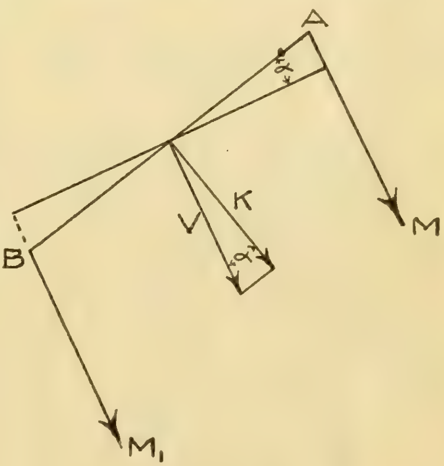

FIG. 14.—Lines AM and BM_1 indicate the known direction of the circulation. K represents the computed velocity normal to the sectional line AB. To find: The true velocity (V) of the current

In Figure 15, AB represents the path of the current; AE, the resultant of the real physical forces; and AC, the quasi force due to earth rotation, acting with the same magnitude but in the opposite direction. The two vectors AE and AC lie in one and the same plane, EAC, which is perpendicular to the course of the current. The fields of forces may be investigated by regarding them graphically in either a vertical view, called a dynamic section (see fig. 12, p. 30) or in a horizontal view called a dynamic topographical chart (see fig. 19, p. 39). Both vertical and horizontal projections, it will be found, assist to reveal particular knowledge regarding the types of forces involved. It will lead also to a clearer understanding of the relative position of the forces, and, moreover, to the course of the current, if we now review some of the fundamental notions pertaining to such representations of forces.

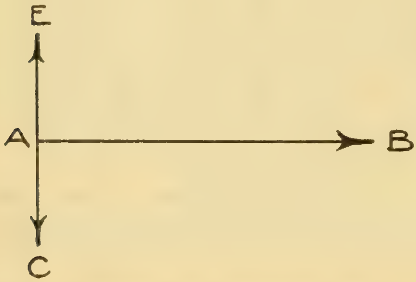

FIG. 15.—Resolution of the two principal forces in a gradient current AB; AE, the forces due to Archimedean tendencies; AC, the Ferrelian force

The well-known method of regarding a force as represented by equiscalar surfaces and unit scalar sheets is especially applicable here. The potential value of an irregularly formed equiscalar surface, obviously, can be traced by its intersections with a series of unit parallel horizontal planes. The rate of variation of contours (intersections) measured along a normal vector called the gradient is a direct expression of the acceleration of the scalar force. In Figure 16

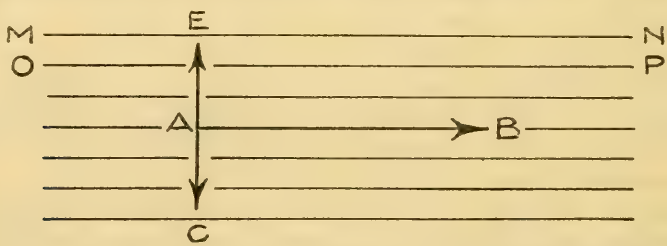

FIG. 16.—A diagram of forces similar to that shown in Fig. 15, but with the addition of dynamic isobaths MN, OP, etc., which show the position of such contours (when friction is disregarded) relative to the actual movement of the water particles

the vector AE representing the acceleration due to primary forces in the sea provoking currents may be regarded as a gradient force due to the variations in level. These variations are in horizontal projection shown by a series of horizontal lines (dynamic isobaths) MN, OP, etc., all perpendicular to line AE, and inscribed on the scalar field of the force. But MN, OP, etc., are also parallel to the line AB, the stream line of the current. Lines MN, OP, etc., then, correspond to the

dynamic contours of a given isobaric surface as illustrated by the dynamic topographical chart described on page 37 (see fig. 19). Therefore it follows that the dynamic isobaths recorded on such charts possess a tremendous significance in as much as they delineate the courses of the water particles over any given area that has been investigated. Not only may the paths of the currents be traced on such charts, but the degree of compactness of the dynamic isobaths along the gradient at right angles to the current, is a measure of the relative velocity of the current. The closer together the contours lie in any given latitude indicates the more rapidly the current is flowing at that time and place.

DIRECTION OF FLOW

The direction toward which the water moves is, of course, requisite information which may be obtained best perhaps by reference to a vertical section—i. e., the dynamic section. If a plane be passed

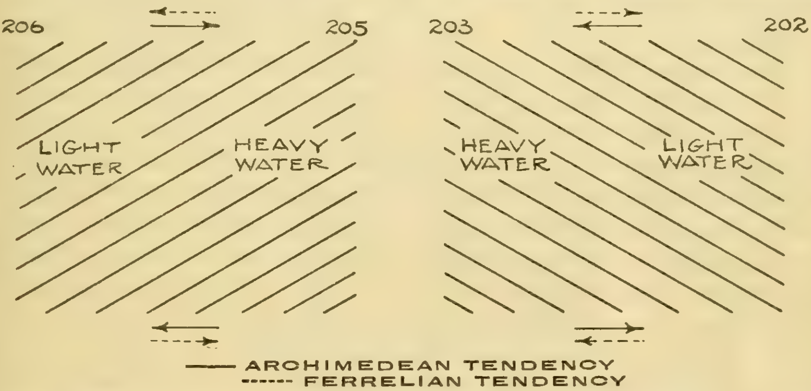

Fig. 17.—Showing the two types of distribution of specific volume in vertical section and the resultant tendency toward flow of the water in consequence

vertically downward through the plane of the forces AC and AE (fig. 16 p. 34) and a distribution of specific volume be secured, a dynamic section similar to Figure 12, page 30, will result. Consideration of the closed curve formed by the two verticals at stations 206 and 205 will reveal the fact that the water being lighter to a greater depth at 206 than at 205 tends to be forced upward at 206 and downward at 205. But when the current is constant there is no actual movement of the water particles in these planes, as the real forces are exactly counterbalanced by the Ferrelian force (effect of earth rotation), the latter of which acts in a direction opposite to the tendency of the Archimedean forces. The real movement of the water particles, as represented by the foregoing figure, takes the form of a current which flows at right angles to the plane of the dynamic section. In such a distribution of forces as shown by Figure 17 the current would run in a direction through the paper, either toward or away from the

eye of the reader. Provided that the water is moving faster in the surface layers than in the depths, the rule follows: Look in the direction toward which the current is running, in the Northern Hemisphere, and the lightest water will always lie on the right hand. The vertical differences of velocity may be calculated from equation (f), see page 24, which is affected fundamentally by the values of temperature, salinity, and depth, at any two verticals in a plane and which it is important to note lies at right angles across the path of flow.

GENERAL SUGGESTIONS FOR A PROGRAM OF HYDROGRAPHICAL SURVEY

Ocean currents, it has been pointed out, may be determined by a distribution of temperature and salinity in a plane, the position of which is perpendicular to the flow of the water. Conversely, if no forces are found as represented by the position of the isosteres and isobars in vertical section, then there is no current at right angles to the plane of the section. It is easy to see, on the other hand, that a section parallel with the course of a current contains no information whatsoever regarding its movement. Hydrographical survey of extensive ocean surfaces involves in any event a large program of time and expense, and the task grows to considerable magnitude, especially when the work devolves upon the efforts of one vessel. An ideal program, of course, includes a maximum number of oceanographic stations distributed netlike over the area to be investigated, and wherein the promulgation of the work most nearly approaches a simultaneousness of observation. Unfortunately, the ideal survey rarely occurs, and it is usual that resort is made to lines of stations along a vessel's track. Under such conditions it is apparent that before commencing the observational work the particular area should be studied carefully with respect to all previous, available knowledge of a hydrographical nature, remembering that the lines of stations in a program of dynamic investigation should run in such a manner that the sections secured approach most nearly to right angles across known or suspected currents. As an example let us take the region around the tail of the Grand Banks where there are two main movements. (1) The Labrador Current is the inshore set, which flows southward along the east side of the Grand Banks and to a variable distance around the "Tail." (2) Offshore in the Atlantic basin the easterly moving masses of the Gulf Stream, guided by the trend of the bottom configuration, progress in a generally opposite direction to the cold water inshore. A program of dynamic investigation in this region should be based upon a series of lines of stations running offshore in a direction normal to the Grand Banks' slopes as shown by Figure 18. Stations should be taken as close together (and repeated as often) as practicable in order that the influence belonging to tem-

porary boundary waves and vortex movements be disassociated from a representative picture of prevailing conditions. (cf. Helland-Hansen and Nansen, "The Norwegian Sea," Bergen, 1909.) To such an end the dynamic features of modern physical oceanography are best carried out by several craft cooperating in one systematic program of investigation, which may or may not extend over great expanses of the ocean. Here is an important requirement which would appear to demand certain revisions in the program of expeditions, which in the past have usually been performed by one vessel sailing under a more or less roving commission. These modern methods in dynamic

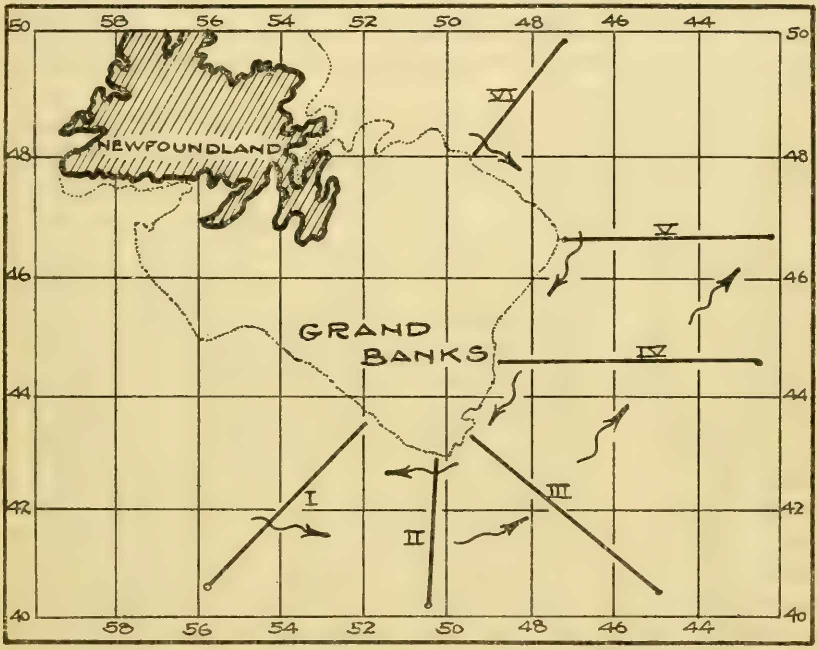

FIG. 18.—A series of station lines radiating from the Grand Banks is an example of the correct methods to employ in order to obtain the best collection of material leading to an investigation of the currents in this region

oceanography, particularly the graphic representation as embodied in the dynamic topographical chart, provide, furthermore, an easy and efficient means of mapping currents over extensive ocean surfaces—advantages which are bound to guarantee a great employment for this science in future hydrographical surveys.

DESCRIPTION OF A DYNAMIC TOPOGRAPHICAL CHART (CURRENT MAP)

We now come to the description of a dynamic topographical chart, a subject which has been reserved until the close of the various methods of illustration, because, from its practical importance, it merits especial emphasis. The basis for the construction of such a projection depends fundamentally on the dynamic computations

previously discussed on page 28. It possesses great practical advantages in that it presents two pertinent, desirable pieces of information, viz, (1) the direction of movement, and (2) the relative rate of flow of the current, over any given area. Let us suppose that the temperature and salinity data, surface to 750 decibars, have been collected from a sufficient number of stations in the region south of the Grand Banks. This, as a matter of fact, corresponds to an actual oceanographical investigation carried out by the International Ice Patrol in these waters during the spring of 1922. Dynamic treatment of these data leads through the accepted methods of calculation as shown on page 28. Column 12 on that page contains the dynamic depths of the successive surfaces of observation, and also the material for the construction of a dynamic topographical chart, of which Figure 19, page 39, is an example.

An isobaric surface, the dynamic topography of which is the subject of interest, may be visualized as spread out beneath the surface of the sea, an undulating floor, the depth of which we plumb with the same reality as the more tangible floor of the ocean is sounded out by the hydrographer. As a first step toward the mapping of currents, let us investigate any one of the standard isobaric planes of observation adopted by the International Ice Patrol, viz, 50, 125, 250, 450, and 750 decibars, by plotting its dynamic soundings on a map at those positions in latitude and longitude where the respective stations have been located. This procedure, it is plainly seen, is identical to that in which depths to the bottom are fixed on any ordinary navigational chart. If, as a next step, equipotential (level) planes are passed at frequent heights through the selected isobaric surface which is under investigation, a number of lines of intersection are formed, which for convenience may be called dynamic isobaths. If now we recall the fact that when the accelerating force of friction is disregarded the movement of water particles on an isobaric surface tends along such a surface, as well as along the same equipotential surface (see p. 34, fig. 16), it is not difficult to appreciate the significance of dynamic isobaths. The small sketch in the lower left-hand corner of Figure 19, page 39, shows a series of dynamic isobaths and the direction of the two forces which are always present wherever there prevails translatory movements of water particles in a steady current. Friction, for all practical purposes, may be disregarded. (See p. 43). (1) AE illustrates the resultant of the forces which impel and maintain gradient flow; (2) AC represents the Ferrelian force acting in a plane 90° to the right of the current; and (3) AB is the path of the actual established movement following along the dynamic isobaths. When these latter are recorded on an ordinary geographical map, as a series of dynamic contours, it permits the reader, at a glance, to picture the course followed by a water particle throughout the region which is under survey. Figure 19 is shown as an example of a dynamic

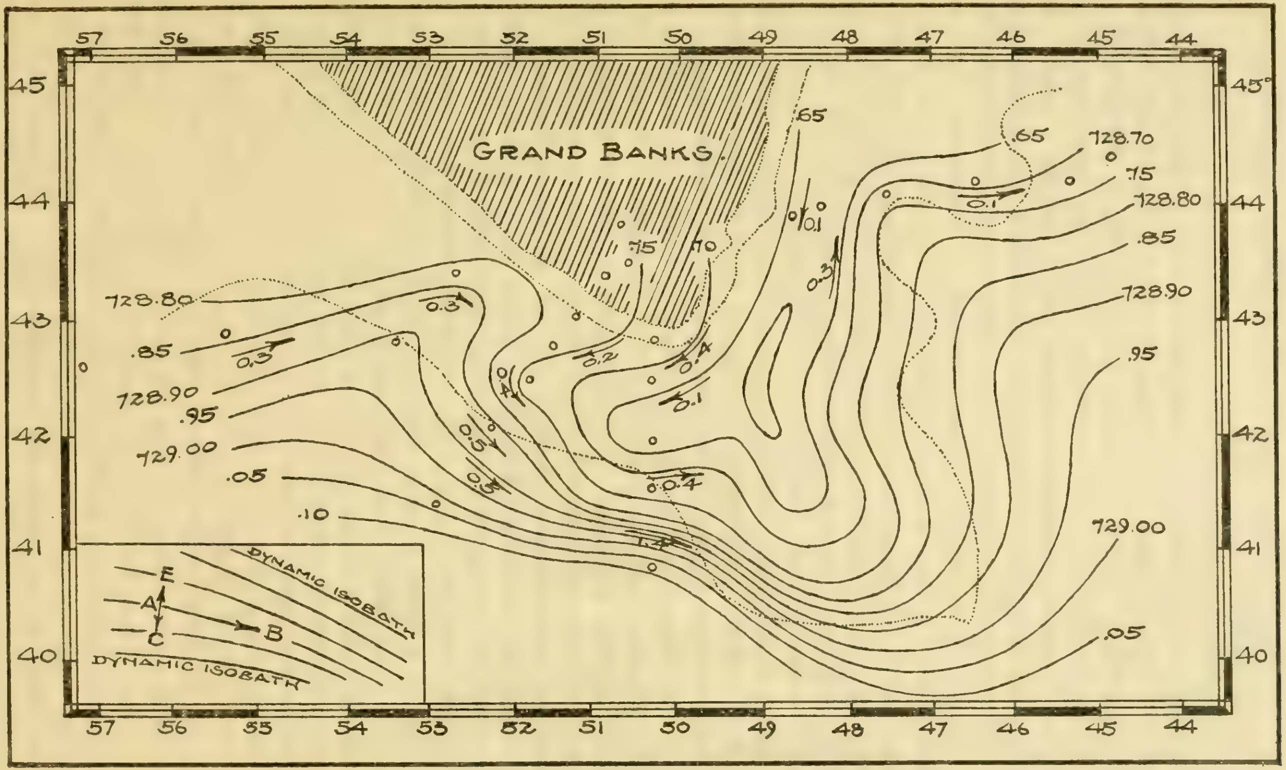

FIG. 19.—An example of a dynamic topographical chart (an ocean current map)

It is interesting to observe that the easterly position of cyclone track B on Figure 6, was due without much doubt to the presence of the aforementioned anticyclone. Weather bulletins were received May 5, 6, and 7, containing information that a depression was forming in the region of Bermuda, but due to the lack of ship reports it was impossible to ascertain definitely the movement of the center. During the night of May 8 our barometer began to fall, which from past experience indicated the approach of a storm within a radius of about 500 miles. The next morning upon constructing the weather map the center was revealed near Port aux Basque; it probably had followed a northerly path from Bermuda as indicated on Figure 6. During the next few days the weather maps indicated a tendency of

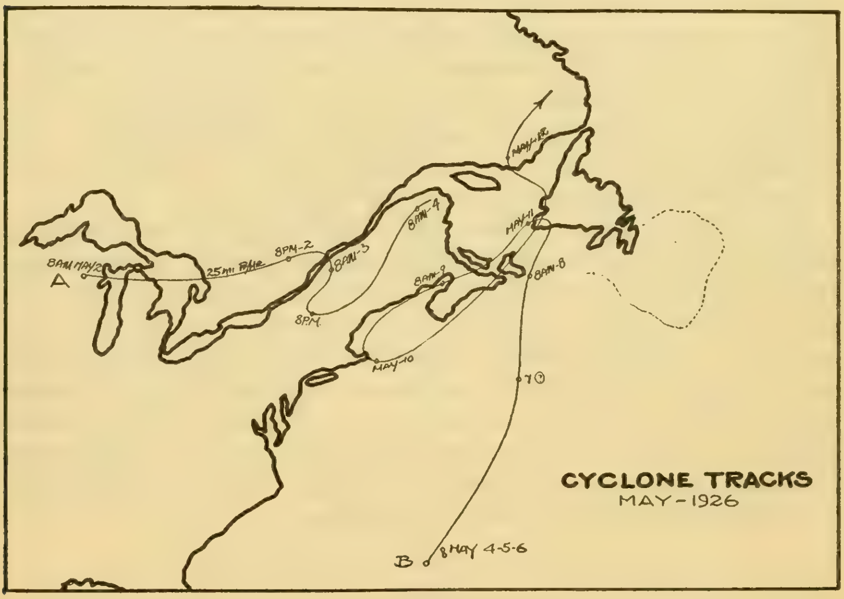

Fig. 6.—May cyclone tracks

the pressure to remain relatively low to the westward, depression centers being recorded from Nantucket to Sydney. On May 11 a deep center appeared near Sydney and moved in a path across the Gulf of St. Lawrence and out to sea. The effects of this distribution set up an indraft of southeasterly winds consisting of warm moisture-laden air pulled across the ice regions from out in the Atlantic. This condition incidently produced the longest period of fog which we experienced for the season.

The two weeks from the 13th to the 27th marked a change in the previously noted tendency of the cyclones to travel consistently along northeasterly tracks Where prior to this period individual centers moved rapidly across the country we now saw several small vortices (families) following meandering paths as if they were the

prey to several factors no one of which exerted outstanding control. For example, on May 13 a slight shallow depression moved from Illinois eastward to the Potomac and the next day spread into a spacious depression with two centers. One traveled eastward while the other remained stationary until two days later it coalesced with a third depression which had been drifting slowly eastward from the Great Lakes. Contemporary with this modification in the weather we noticed that the wind velocities in general had gradually become less than they had been earlier in the season.

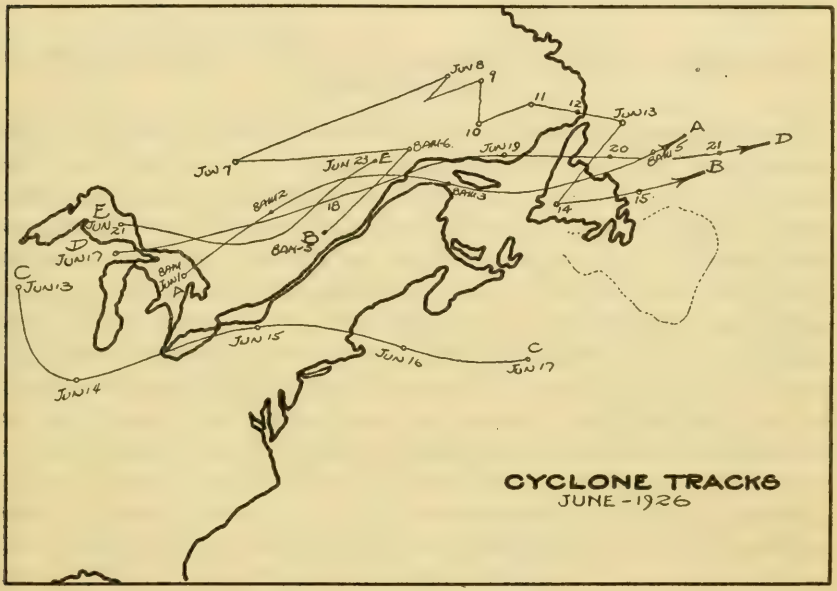

FIG. 7.—June cyclone tracks

May 25 to 30 an anticyclone of vast proportions expanded from the region of central Canada and spread over the entire eastern half of the United States and extended out to include the ice regions. It finally divided into two centers and soon afterward disintegrated completely. It is interesting to examine the flatness of the barograph curve and the presence of clear weather, both of which are recorded on Figure 3, page 35.

JUNE

The most important lesson contained in the cyclone tracks for June (fig. 7) is obtained by comparing the position of the average with the position of the average for the months of March and April. It is clearly indicated that a migration to the northward of the mean cyclone track took place in the course of two months. It is estimated as approximately 150 miles. The explanation for track C, Figure 7,

Gulf Stream, and is well illustrated by the velocity diagram (fig. 13, p. 32). In "B," Figure 20, the velocity of "a" being greater than adjacent particles, or adjacent sheets above and below, is thereby retarded and friction acts to hinder the translatory progress of particle "a." In "C," the velocity of particle "a" is less than either of its immediate neighbors, above or below, and friction therefore

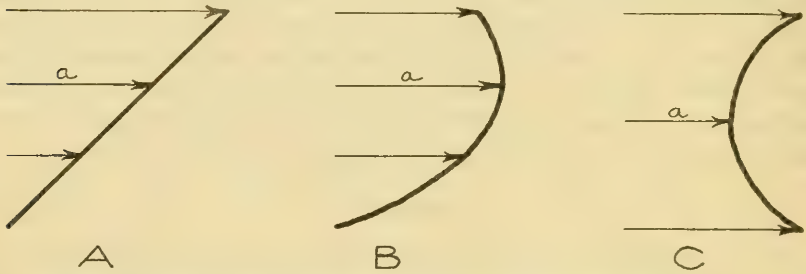

FIG. 20.—Three general types of current velocity diagrams

tends to accelerate the velocity of "a." If the water particles in a current be retarded by a constant accelerating force of friction throughout the depth, then the velocity diagram will assume the form of a parabola.

Cases as shown in "B" and "C" (fig. 20) may also be illustrated by components and force diagrams in horizontal projection as follows:

The dotted lines in Figure 21 represent the direction of flow of the current, and the solid lines are equipotential lines inscribed on the scalar field of the force tending to produce a movement in the sea.

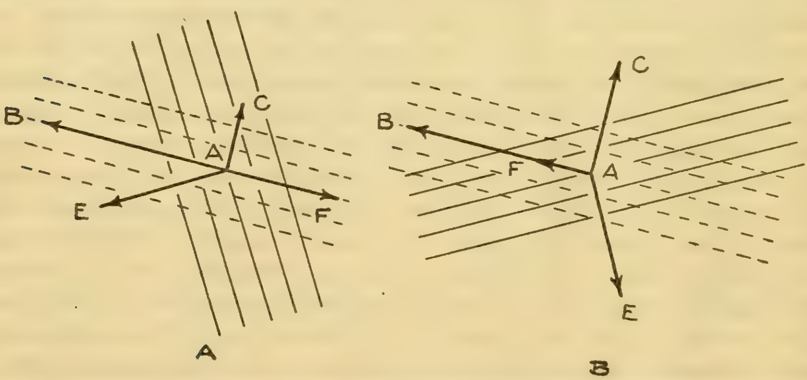

FIG. 21.—The two types of force diagrams belonging to gradient currents when friction is included either as (1) a retarding or as (2) an accelerating force

The gradient AE being perpendicular, of course, represents the force due to variations in gravity potential. AC is the force due to terrestial rotation lying 90° to the right of the direction of the current. By vector analysis we may find the force AF due to friction, where in "A" it retards the current AB, and in "B" it accelerates the same. If all but one of the parallel lines of flow and all but one of the parallel

equipotential projections be removed, the angle between these two may be more easily seen and designated as α, in the figure. It follows that:

$$AF = AC \tan\alpha = 2\omega \sin \varphi V \tan \alpha \text{ .... (h)}$$

It is seen from this that the force due to virtual friction varies directly as the tangent of α and the velocity of the current. There is, however, very little data bearing on the value of this angle α for various currents at different places and under different conditions. In order to determine various values of α (contemplating of course that there are several assumptions), simultaneous observations should be made regarding the direction and the rate of flow of the current with the aid of current meters, and at the same time observations for temperature and salinity should be taken in a section at right angles

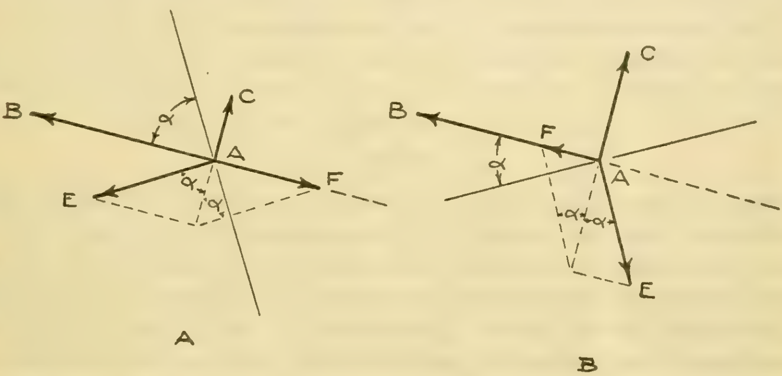

FIG. 22.—An illustration similar to Fig. 21, but with all but one of the dynamic isobaths erased and all but one of the parallel lines of flow erased

across the current. By such a means the virtual friction, as represented by the line AF, can be tabulated directly. The value of this effect, however, as it enters the present discussion, may be safely stated, rarely exceeds a magnitude of 0.05 to 0.07 knots per hour, either to accelerate or to retard the flow of a steady current, and such ciphers being relatively insignificant can be disregarded in the practical determination of currents.

EFFECT OF BOTTOM CONFIGURATION ON CURRENTS

Frictional retardation attains considerable proportions, however, between flowing water particles in contact with the fixed configurations of an ocean basin. Ekman has suggested as a result of mathematical investigations that if an ocean current proceeding along in a steady manner moves in over a gradually shallowing shelf, it will tend to be deflected more and more to the right in the Northern Hemisphere. On the other hand, if by a continuance the bottom begins to recede deeper and deeper from the surface, then the current will be proportionately deflected to the left. This phenomenon

is revealed by reference to certain current charts (dynamic topography) of which the Ice Patrol has record. As an example, we might call attention to Figure 19, page 39, wherein the position of the Gulf Stream relative to the 4,000-meter contour, clearly indicates that the current flooded in up the grade occasioned by the southeasterly extension of the Grand Banks (about 53° west longitude), but meeting increased resistance in the constantly shallowing depths it was deflected to the right, offshore. The current, proceeding along in this new direction where the depths increase, tended to swing to the left, inshore; and so in this fashion its course may be traced as it flowed along the continental slope in a serpentine path.

Inshore, over continental shelves, it has been found that the coastal waters are in a slow primary circulation which Huntsman believes due to the pumping action of the tides combined with the effect of terrestial rotation. It has been expressed in a general statement, viz, bottom configuration in the Northern Hemisphere tends to deflect currents to the right (cum sole), around islands and shoals, and to the left (contra solem), around basins and deeps.

TIDES

One of the external forces provoking currents in the sea was ascribed to the tides (see p. 1). Such currents rotate in their movement either clockwise or counterclockwise one complete cycle, when unaffected by other influences, in a period of 12.4 hours. The theory of semidiurnal tides is based upon a series of waves which are known sometimes to be propagated great distances, but the discussion of the form of such waves, and the theory of orbital motion given to the water particles, is too lengthy to be included in this paper. Those interested in a more detailed exposition are referred to Darwin (cf. Tides and their Kindred Phenomena in the Solar System.) We may remark, however, a few generalities regarding the various tidal phenomena as they affect certain oceanographical problems. Tidal currents in the deep ocean basins are of comparatively subordinate importance, but near continental slopes and over shelves they may attain great magnitude. Even when such slopes and shelves extend far out into an ocean basin, tidal effects remain quite prominent. The sheet of water lying over the Grand Banks, for example, averaging a thickness of about 35 fathoms (65 meters), receives a regular tidal clockwise rotation which attains velocities ranging from 0.2 to 0.5 knots per hour. Well-marked rippling on the surface during periods of calm sea, moreover, has been observed along the eastern edge of the Grand Banks, which it is easy to believe were caused by the semidiurnal tidal wave meeting the rise as presented by the eastern face of the bank. Icebergs around the Grand Banks have often been carried inshore and grounded temporarily during calm weather when no other cause seemed so plausible as that of a favorable tidal set at the time and place.

Various places, as a result of land and shoal formations, may be under the influence of two tidal waves in varying phases. If these latter are similar and both at a maximum, then follows a maximum range of level and a minimum velocity of current. On the other hand, where two tidal waves meet in opposite phases, a minimum range of level results but a maximum strength of current is attained. Tidal currents on soundings are usually determined by the aid of current meters, which in the open sea are often illustrated by an elliptical form of diagram when the current is purely tidal. The water over shelves and near continental slopes is usually in progressive movement as well as being under a tidal influence, and in those cases the current diagram will be a resultant of the two different types of movement. Another method of illustration of current observations is that of a number of vectors radiating from a common center and where the position and relative length of the successive vectors indicates the direction and velocity respectively of the current reckoned in moon hours.

VARIATIONS IN ATMOSPHERIC PRESSURE

Among the causes of currents ascribed to external forces, there was included (see p. 1) that of the atmosphere as it pressed down upon a sea surface unequally. Some very interesting observations have been collected which deal with this subject where the bodies of water are partially inclosed by basins and the currents thus produced are forced. An example of such geographical qualifications is illustrated by the Mediterranean Sea and its connection—the Strait of Gibraltar—with the Atlantic. Knudsen has found that atmospheric pressure differences between the Baltic and the North Sea can be traced in the acceleration (or retardation) of the current through the Belts and Öresund. Since a difference in atmospheric pressure of 1 centimeter of mercury is equal to about 13 centimeters of sea water, it is not difficult to appreciate that the volume of a water mass which has this dimension as a thickness and an area equal to the Baltic will cause a considerable current when forced through such an opening as Öresund. Apparent natural difficulties have prevented the collection of scientific observations which will throw light upon the degree of this influence in the open sea. Because of (*a*) the absence of boundary surfaces against which the variations in atmospheric pressure may react; (*b*) the compensating effect which results from the progressive movement of such maxima and minima areas over the sea's surface; and (*c*) a counteracting drift current which tends to flow as a result of the accompanying system of winds make it safe to state that in general the relative importance of variations in atmospheric pressure causing currents in the open sea is small indeed. This phenomenon can be totally disregarded in hydrodynamic computations of the ocean.

WINDS

The discussion of the most important of all forces classified as external and provoking currents in the sea—the winds—has been reserved until the last. Winds, as they are treated in this connection, are divided into two groups: (*a*) Those winds the effects from which impel the surface layers—propagate frictionally downward—and produce a drift current only; and (*b*) those winds which by virtue of (*a*) drive water particles against boundary surfaces in the sea and give rise to gradient currents.

Let us first examine (*a*) the current caused by the wind and the earth's rotation alone. Nansen, on board the *Fram* while held fast in the Arctic pack, observed that the drift of his ship was 20° to 40° to the right of the direction of the wind. More recently Ekman has made some very interesting theoretical investigations regarding a wind blowing tangentially over a water surface, taking the rotation of the earth into account. (See Ekman's "Earth Rotation and Ocean Currents," Arkiv för Matematik, Astronomi, och Fysik, Band II, No. 11, Uppsala, 1905.) To begin with, Ekman has made the following assumptions:

1. The ocean be unlimited in a horizontal direction.
2. The depth to the bottom be great.
3. The water mass be homogeneous.

The following deductions are then made:

(*a*) The surface water particles are driven 45° cum sole (to the right in the Northern Hemisphere) of the direction of the wind.

(*b*) This effect is propagated frictionally downward. The direction of the current will alter cum sole in direct ratio to the increase in depth, and the velocities will decrease in geometrical progression.

(*c*) At a certain variable depth, called the frictional depth (or depth of wind current), the water will flow in a direction exactly opposite to that of the surface current, but its velocity will be only about one-twenty-third of that on the surface.

In order to obtain a clearer conception of the penetration of wind currents in the upper levels of an ocean, relative values of c (the velocity of the drift current throughout the vertical range of frictional depth) and D (the frictional depth) may easily be calculated by means of Ekman's formulæ and placed in table form:

TABLE VIII

Direction			Velocity
Meters	α^*	α'	C
0	0	0	C_0
0.2 D	0.2 π	36°	0.53 C_0
0.4 D	0.4 π	72°	0.28 C_0
0.6 D	0.6 π	108°	0.15 C_0
0.8 D	0.8 π	144°	0.08 C_0
D	π	180°	0.04 C_0

(*the direction of the wind current at the very surface is assumed to be 45° to the right of the wind). Angles a and a' are the differences between the direction of the surface current and that prevailing at the given fractions of the frictional depth. The same results were first shown graphically by Ekman in the form of a diagram, a copy of which is shown herewith. As an example of the use of Table VIII, and as further illustrated by Figure 23, if the frictional depth be 50 meters, then at a depth of 10 meters the water particles will flow in a direction 36° to the right of the current on the surface. So it is seen that if the surface velocity and the frictional depth be known, the velocity and the direction of the pure drift current throughout the vertical range may be determined. Ekman has found that for practical purposes the equation may be simplified to

$$D=\frac{7.6\,W}{\sqrt{\sin\phi}} \text{ - - - - - - - - - - (j)}$$

(j) is based upon the value of q equal to 1.025; and W represents the wind velocity in meters per second. It is easy to see from (j) that the greater the wind velocity the deeper downward in an ocean will its effect penetrate. Also since sin ϕ is zero at the Equator and 1 at the pole, it follows that given winds will exert a maximum influence at the Equator and the least effect at the pole. The density of the water is of some importance; a given wind current will be stronger and penetrate to a greater depth in a region of light water than in a region of heavy water. Table IX gives

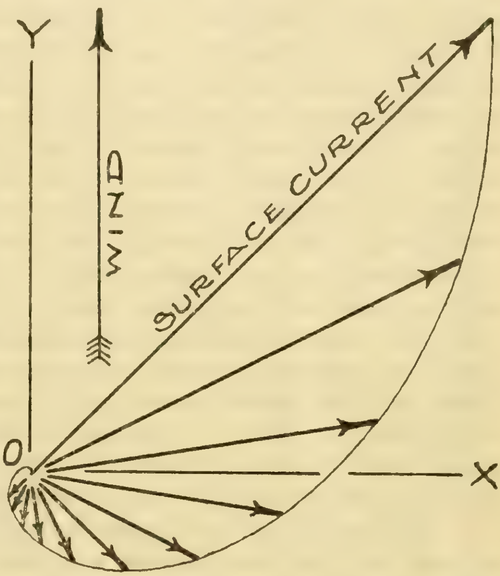

FIG. 23.—Ekman's diagram in which the position and length relatively of the successive arrows represent the direction and velocity, respectively, of the pure drift current, down to the frictional depth, set up as a result of wind and earth rotation alone

TABLE IX

Wind velocity		Latitude										
Cm. sec.	Beaufort	1°	5°	10°	20°	30°	40°	50°	60°	70°	80°	90°
5	3	238	129	91	65	54	47	43	41	39	38	38
10	5	575	257	182	130	107	95	87	82	78	77	76
15	7	863	386	274	195	161	142	130	123	118	115	114
20	8	1,151	515	367	260	215	190	174	163	157	153	152

the frictional depth for different wind velocities at different latitudes and is computed by means of equation (j). The table is also based upon several assumptions, two important ones of which are, (1) the water mass be homogeneous, and (2) the depth to the bottom be great compared with the frictional depth. Such restrictions, as a matter of fact, differ from conditions actually met in the ocean, but the table gives an idea, nevertheless, of the depth of the pure wind current in the open sea, bearing in mind that when great variations in the density are found, the frictional depths will be less. At such places where abrupt transitions in the density of a water column takes place (e. g., a well-pronounced condition during the summer when the superficial layers become relatively light), then the boundary between the surface water and the heavier underlying mass acts as a virtual bottom in determining the development of the pure wind current. The density curves for the Grand Banks column, for example, often reveal an abrupt transition at a depth of about 20 to 30 meters, and such a discontinuity layer probably indicates the lower limit of the drift current at the time. If the depth of the upper layer be less than the frictional depth, as found by Table IX, then the effect of earth rotation is small and the direction of the wind current will more or less parallel the direction of the wind. On the other hand, at those places where homogeneous water is found extended downward 200 or 300 meters (e. g., in an ocean which has been subjected to the effect of an entire winter's cooling), then we may expect wind currents (after a day or so outside of the Tropics) to develop in characteristic form. (See fig. 23. p. 47.)

A distinction has been made between (*a*) the direct frictional effect of the wind blowing over a surface in the deep open sea, as it sets in motion a pure wind current, and (*b*) a similar effect of the wind but under the influence of coast lines or other hinderances, by which the water becomes amassed against (or sucked out from) such boundary surfaces in the sea. Winds classified as (*b*) bring to the problem a consideration of two subsequent movements known as "the mid-water current" and the "bottom current." The bottom current compensation for the surface current as the latter flows toward (or away from) boundaries. As an example of the building up ability of far reaching currents by a system of prevailing winds, we might regard the northwestern North Atlantic region along the North American coast, stretching from Baffin Land to the southern reaches of Newfoundland. Normal atmospheric distribution, especially well marked in this region during the December–March period, furnishes a strong northwesterly wind component, which a glance at the map will show lies approximately parallel to the coastal trend, Baffin Bay to Cape Race. Ekman has pointed out (see "Earth Rotation and Ocean Currents," Arkiv för Matematik, Astronomi och

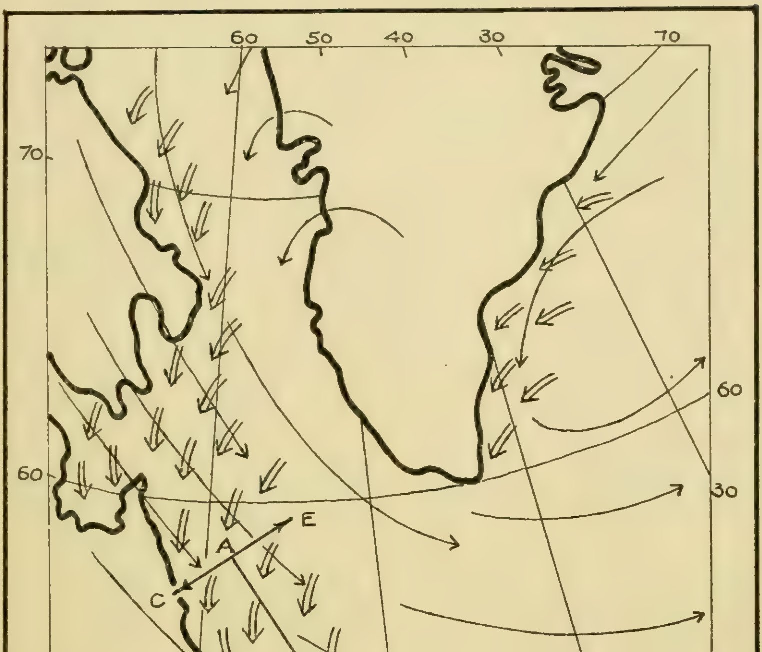

FIG. 24.—The northwestern North Atlantic region illustrated in such a manner as to present one of the fundamental factors causing the gradient Labrador Current. The long curved arrows indicate the average wind direction December–March, and the short double arrows show the general movement of the water as a result. The diagram AB—CE represents the relative positions of Archimedean and Ferrelian forces and the direction of gradient flow

Fysik, Band II, No. 11, Uppsala, 1905) that the influence of a coast line upon currents set up by the wind is to produce a general movement of the water along in the direction of the coastal trend. The bulk of the current—i. e., the mid-water current—flows more or less parallel to the coast line, but as we approach the shore the mid-water current disappears and the surface and bottom systems merge into one with a consequent loss of character. This last-mentioned movement also tends to flow parallel to the shore line. A wind of given strength will produce a maximum effect, states Ekman, when directed 13° to the left of the coast line, which conditions, it is interesting to note, accord closely with relative directions of winter wind and coast line in the northwestern North Atlantic region. Figure 24, page 49, illustrates this particular phenomenon. The long curved arrows represent the average direction of the wind during the December–March period, and the short double arrows indicate the general movement of the surface layers. Offshore, where the depth to the bottom is relatively great, the wind current at the surface will be deflected nearly 45° to the right of the wind, and the mean transport of the water layer of the wind current will most nearly approach a direction 90° to the right of the wind. As we near the shore and shallow water the direction of the wind and movement of the surface water tend to become parallel. The gradient current, which is the most voluminous of the movements, arises whenever the sea surface, which has been deformed into a state of obliquity by the wind, tends to return to the level. A regular state of motion is soon established with a steady flow perpendicular to the pressure gradient, and we are permitted to draw a diagram showing the position of impelling and Ferrelian forces, AE and AC, respectively, with resultant direction of the gradient current as line AB. The time required for such a development must be calculated in weeks or months depending upon the magnitude of the wind and the width of the current. Gradient currents are more or less independent of slight variations in the winds such as affect surface currents, but it is quite probable that variations in the circulation of the atmosphere are followed by corresponding variations in the gradient currents. As an example of such a phenomenon as described in the foregoing we point to the Labrador Current, which may be due to the melting of polar ice, but which, nevertheless, is controlled to a great degree by a system of seasonal winds, December–March, tending to aid the transport of cold water and ice out of the Arctic along the western side of the North Atlantic basin.

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TREASURY DEPARTMENT - UNITED STATES COAST GUARD

BULLETIN No. 15

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN - [SEASON of 1926]

TREASURY DEPARTMENT
UNITED STATES COAST GUARD

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INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE

IN THE

NORTH ATLANTIC OCEAN

Season of 1926

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1927

SOURCE OF ICE-BERGS AND THEIR DRIFT INTO THE NORTH ATLANTIC.

PLATE I

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FOREWORD

The London Convention of 1914, the recommendation of which paved the way for the United States to undertake the direct operation of a patrol of the ice regions of the North Atlantic, also went on record in favor of a scientific program and the publication annually of a report of the patrol work. In accordance with the latter feature a bulletin has been published after the expiration of each one of the patrols since 1913.[1] The bulletin herewith follows the customary arrangement of the subject matter of those appearing in former years. First comes the general program and statement of policies which have in the past 13 years become pretty well established. Then follows a narrative of the events which occurred during a total of the seven cruises that made up the patrol for 1926. A brief account is given of the radio operations for the season, a subject which obviously is a vital one when estimating the patrol's efficiency. The oceanographic work this season was featured by the application of new and progressive methods[2] to map the currents in the so-called critical area around the Tail of the Grand Banks.

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[1] Copies are obtainable free of charge from Commandant, U. S. Coast Guard, Washington, D. C.

[2] Smith, Edward H.: "A Practical Method for Determining Ocean Currents." U. S. Treas. Dept. Bull. No. 14.

THE INTERNATIONAL ICE PATROL

1926

The International Ice Patrol for the season of 1926 was carried on by the United States Coast Guard cutters *Tampa* and *Modoc;* the former was in command of Commander H. G. Fisher, and the latter was in command of Commander H. H. Wolf. The Coast Guard cutter *Mojave* was designated as the stand-by vessel. Lieut. Commander Edward H. Smith, was detailed to assist and advise the commanding officers while on patrol.

As in former years the object of the patrol was to locate by scouting, and radio information, the icebergs and ice fields nearest to and menacing the North Atlantic lane routes. In doing this it was necessary to determine the southerly, easterly, and westerly limits of the ice and to keep in touch with it as it moved southward. Radio broadcasts were sent out twice daily giving the whereabouts of this ice and particularly that which was in the immediate vicinity of the North Atlantic lane routes. In order that an intelligent service of the highest degree be rendered to shipping, an oceanographic program was laid down the results of which, it was hoped, would furnish the vessel on patrol with a practical up-to-date current map of the critical, infested ice area under surveillance. The oceanographic work being supportative and secondary in importance was so arranged that it would not hamper the patrol in its primary duty of ice scouting.

A scientific program from which conclusions of practical value may be drawn is an established policy of the ice patrol. The work carried out in 1926 progressed along two general lines:

(*a*) Sonic depth recorder experimentation. The ice patrol was equipped with one sonic depth recorder in 1925 in order that experimental tests be carried out which might lead to the design of a practical device for determining the proximity of bergs not visible because of fog, snow, or darkness. It was found impossible to continue with this phase of the sonic work in 1926, but about 450 hydrographical soundings were taken in order that an accurate and authenic map of the ice regions around the Grand Banks may ultimately result. (See pp. 49 to 52.)

(*b*) Oceanographic work: If the patrol had knowledge of the drift tracks which bergs would follow after arrival at the Tail of the Grand

Banks, more valuable information could be furnished approaching vessels, especially during the protracted periods when fog enshrouds the cold-water regions. Since nearly all the bergs at this gateway to the Atlantic are controlled by a relatively deep-seated circulation, a current map of the critical area where the Labrador current and the Gulf Stream meet, is an indicator of the courses menacing bergs will follow. A practical means of determining oceanic circulation in critical areas was instituted for the first time with the season of 1926. (See pp. 108 to 117.) The methods of this work [1] are set forth in a pamphlet recently published by the Coast Guard.

After the ice was located the patrol began transmitting four daily radio broadcasts, giving ice information for the benefit of shipping, each broadcast being repeated once with an interval of two minutes between the messages. The times at which these broadcasts were sent and also the wave lengths used are given below:

Greenwich civil time	Time seventy-fifth meridian	Wave length	Frequency
		Meters	*Kilocycles*
0000	1900	1,713	175
1100	0600	706	425
1200	0700	1,713	175
2300	1800	706	425

In addition to this service ice information was given to any ship that made inquiry and in cases where vessels were standing dangerously close to ice, the patrol sent them a special message.

The ice patrol in transmitting routine dispatches to Washington operated under the following schedule which had been arranged before the ships sailed from port. After getting the "XA" set in working order a slightly modified schedule superseded the one here. (See p. 16.)

Greenwich civil time	Time, seventy-fifth meridian	
1300	0800	Ice patrol transmits Weather Bureau report to Bar Harbor on 175 kilocycles (1,713 meters), using the "no answer" method.
1700	1200	Washington transmits "no answer" method acknowledgement for 0800 schedule on 113 kilocycles (2,650 meters).
1800	1300	Ice patrol receipts by "no answer" method to Bar Harbor receipt for Washington's 1200 schedule. Use 175 kilocycles (1,713 meters).
0100	2000	Ice patrol transmits "no answer" method to Bar Harbor on 175 kilocycles (1,713 meters), dispatch for Weather Bureau and Hydrographic Office.
0300	2200	Washington transmits "no answer" method acknowledgement for 2200 schedule on 113 kilocycles (2,650 meters).
0330	2230	Washington transmits "no answer" method, a weather forecast for the ice patrol, 113 kilocycles (2,650 meters).
0400	2300	Ice patrol receipts by "no answer" method to Bar Harbor for Washington's 2230 and 2300 schedules.

[1] Smith, Edward H.: "A Practical Method of Determining Ocean Currents." U. S. Treas. Dept. Bull. No. 14.

A more detailed account of the radio activities for the season of 1926 are contained in the section devoted to radio communications, page 14.

A full and detailed description of the behavior of icebergs in the currents in 1926, together with illustrated sketches is contained on pages 53 to 77.

The principal features of the ice patrol season of 1926 have been taken from the detailed reports covering the seven cruises that were made, and this narration forms the first section of this bulletin.

The detailed discussion of the weather, ice observation, results of sonic sounding work, and the oceanography have been grouped together in sections that follow consecutively throughout the bulletin.

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CRUISE REPORTS

THE FIRST CRUISE, "TAMPA," MARCH 25 TO APRIL 11, 1926

In accordance with headquarters telegram the *Tampa* sailed from Boston at 11.55 on the morning of March 25, 1926, and stood out to sea setting a course from the harbor entrance for the Tail of the Grand Banks. Thus was inaugurated the season of 1926. On the second day out we received the first steamer's report of icebergs which referred to a group of seven located on the eastern part of the Grand Bank between latitudes 45° and 43° 30′. This same information was contained in the radio broadcast from Arlington and so it was thought to be the real reason for dispatching the first of the patrol ships to the ice regions.

Sunday, which was our fourth day out, found us about 200 miles west of the Tail of the Grand Banks and there we stopped for an hour to take the first oceanographic station of the year (No. 554), and especially to give new members of the *Tampa's* crew an opportunity during good weather and daylight, to see the manner in which the station work is performed. In the afternoon dispatches were addressed to the wireless officer, Halifax, Nova Scotia, officer in charge compass station, Cape Race; commercial radio station, Cape Race; and the French radio station at St. Pierre, informing them all that the ice patrol ship had now arrived in the ice regions and the same service as rendered to shipping in previous years would be carried out.

Early in the morning of March 29 we arrived at the position of oceanographic station No. 555, located about 75 miles off shore of the southwestern edge of the Grand Banks. It was blowing with gale force at the time and in order that an up-and-down cast be secured the vessel was maneuvered head to the wind and sea with sufficient headway only to prevent her from "falling off." A careful and quick management of the helm under such conditions is necessary, but the maneuver was easily affected and the sounding work carried out with excellent results. When the third station, this same day, however, was to be taken just south of the Grand Banks, it was found that the oceanographic electric winch was burned out. More careful investigation proved the trouble to be so serious that the oceanographic program for the remainder of the cruise would have to be abandoned. Added to this information came the news that

the motor starter of the sonic depth finder had broken. New parts for both these defective ones were the subject of dispatches sent to Washington that night.

An eventful day was March 31 when at 1.55 p. m. we received an S O S flashed from the steamer *Laleham*, without lifeboats and foundering in latitude 39° 06′, longitude 56° 42′. We immediately headed toward the spot and increased speed but other ships (including the *Mauratania*) much nearer responded to the call. At 9 a. m. the steamship *Shirvan* reported having completed the rescue of the crew, so we headed back toward the Tail of the Bank. On account of the S O S call no evening ice broadcast was sent, this being the first time in the history of the ice patrol that such a situation has arisen.

Easter Sunday dawned bright and clear, decidedly the best day experienced so far on the cruise. We started early in the morning searching northward along the eastern side of the Banks, 10 miles seaward of the 100-fathom contour, in a zone which has come to be recognized as the heart of the cold current which bears the freight of ice southward. And so it proved this day, for at 2.45 o'clock in the afternoon the patrol sighted the first ice of the season in the form of broken Arctic fields. The position of this southern tongue was recorded as latitude 43° 59′, longitude 48° 55′. The next morning we ran up to the edge of the ice and from sights found that it had drifted southward during the night at the rate of 1 knot per hour. We steamed about 30 miles northward inshore of the ice skirting its western limits, and returned before nightfall to a position southward of the southern edge. This ice had a very short survival for on the 8th we searched this same area and nothing of it could be seen.

The first and only bergs sighted on the first cruise were raised by the masthead lookout about 2 p. m. on April 9. There were three small bergs in latitude 44° 10′, longitude 47° 51′, which were drifting northeastward at the rate of 0.7 knots per hour. The fact that this ice of small size was floating in water with a temperature of 51° F. (the northern edge of the Gulf Stream), coupled with the report that the *Modoc* was standing eastward to relieve, caused us to head westward this same night and the following day.

The *Tampa* was relieved of the patrol duty the morning of April 11 just to the westward of the Tail. During the cruise we received eight reports of ice from passing vessels; furnished ice information to four ships and received a total of 617 reports of sea-water temperatures.

THE SECOND CRUISE, "MODOC," APRIL 11 TO 25, 1926

After relieving the *Tampa* the *Modoc* was anchored temporarily in on the Grand Bank, but the wind began to freshen on April 12 and before daylight it was found more comfortable to get under way and

head into a moderate westerly gale. The day was spent in this manner with sufficient steerageway only to hold the ship's head up to wind and sea. Due to the fact that we were on the shallowest part of the Bank, the waves were very short and "cobbly," and one sea larger than the others caught our starboard bow just at the right moment, breaking on board and washing a deck box aft beyond the galley. It also bent over and fractured a stanchion which held the forward part of a small canvass awning spread between the cabin and rail. Under such weather conditions as prevailed this day any plans for carrying on a program of ice scouting were forced to be postponed.

April 13 provided better weather and so a start was made to search part of the icy current. At 3 o'clock in the afternoon we reached a position for heading northward along the eastern edge of the Bank, and we paused long enough to hold memorial services for the *Titanic* dead. This ceremony has now become a more or less established custom of the ice patrol vessel each year, and as usual a message was broadcasted to passing ships requesting them to observe a respectful silence from 0700 to 0715 Greenwich civil time, while the actual rites were being paid on the *Modoc*. Early this morning the steamer *Alaunia* informed us that she was stuck fast in an ice field which was located to the south and west of the entrance to the Gulf of St. Lawrence (Cabot Strait). Later this same day this ship discovered a lead and freed herself in open water. Everything was all right with the *Alaunia* when on April 14 she sent the patrol a radio that she had left behind the last of the St. Lawrence fields and was then proceeding eastward past Cape Race.

The *Modoc* made an excursion to the eastward of the Grand Banks on the 14th to the 17th in search of three small bergs reported by a passing vessel. The cruise was a fruitless one as the ice was not located. A great deal of fuel was expended in returning to the westward because of bucking the strong westerly gales and mountainous seas. We finally reached the east edge of the Bank on the 19th instant where the ship remained anchored for the next four days.

The weather made a change for the better on the 22d which was in agreement with the atmospheric pressure distribution as outlined on the meteorological map. This plainly indicated that the pressure gradients were quite small and the progressive movements of the centers of low pressure were relatively slow. All of this pointed toward the advent of summer time conditions and marked a great change from the weather that had prevailed since the inauguration of the patrol. Many reports were received this day from ships on track E bound for St. Lawrence ports. As they crossed from the deep water of the Atlantic on to the continental shelf they sighted

considerable ice, all of which has been listed in detail in "Table of ice and of other obstructions," pages 21 to 30.

The *Modoc* had an opportunity on the 23d instant to search northward along the eastern edge of the Bank for menacing ice. We proceeded northward as far as the forty-fifth parallel but found nothing. We could do nothing more in this line because of foggy conditions, so on April 24 the ship was headed westward in order to meet the relief. The *Tampa* was met about 4 in the afternoon of the 25th. During this cruise the *Modoc* received a total of 53 reports of ice sighted by passing vessels, furnished information to 16 ships, and received a total of 950 reports of sea water temperatures.

THE THIRD CRUISE, "TAMPA," APRIL 25 TO MAY 10, 1926

After effecting the relief and assuming the duties of patrol ship the *Tampa* was kept off on a course for the first one of several oceanographic stations arranged in positions around the Bank in accordance with a previously arranged program. In view of the fact that no ice was south of the forty-fifth parallel and also that there had been considerable postponement in the oceanographic work, the patrol decided the work better be commenced while opportunity existed. Bergs, moreover, were to be expected soon invading the waters around the Tail and it was desirous that the patrol vessel have on board a current map of this critical area.

The next nine days were mostly devoted to collecting data of temperature and salinity from several depths at stations scattered netlike around the Grand Banks. During this period the work was delayed by the presence of a fog and near the latter part of the investigation a strong westerly gale was encountered. While heading the gale on the 2d of May a report was received from the steamship *Rousillon* regarding the position of an iceberg on the east side of the Bank in latitude 44° 10′. This was without doubt one of a group of five bergs that had previously been reported by Cape Race track steamers but it was the southernmost berg so far for 1926 and in that respect was a point of interest for the patrol.

A fog prevented us searching for this berg and so we waited until conditions became clearer. During this period the oceanographer with the data collected calculated the direction and rate of flow of the water in the regions surveyed and a map of the currents was drawn and posted for the information of those in charge of the patrol work. This is the first time in any expedition that the results have been immediately determined on board ship for practical employment.

May 7 the *Tampa* was near the fishing fleet and one vessel was spoken and another was boarded. Sea stores were traded for fresh fish and we anchored for the night in on the Bank. The oceanog-

rapher gave a 15-minute talk this same evening on the history of the ice patrol and general behavior of Arctic ice south of Newfoundland.

Nothing could be done during the day of the 8th on account of fog but the 9th it cleared, the very same day that the patrol ships were meeting on the southwest side of the Bank. Two reports were received from steamers on the east of the slope which had sighted bergs and which plainly indicated that the ice was beginning to drift southward around the Tail. The *Tampa* during the third cruise for the season covered about 1,255 miles, and took 24 oceanographical stations. There were 54 ice reports received and 9 ships were given special ice information. A total of 835 surface temperature reports were contributed by passing vessels. We requested that 22 steamships give receipted acknowledgment for the ice broadcast because their courses were laid near the ice danger zone.

THE FOURTH CRUISE, "MODOC," MAY 10 TO 25, 1926

The *Modoc* met the *Tampa* the morning of May 19, 120 miles west of the Tail, where the oceanographic party was received on board and the relief effected. As soon as the boat was hoisted the *Modoc* was headed eastward with plans to search the region around the Tail the next day. Unfortunately a dense fog shut in before the close of the day which necessarily suspended all searching work. Foggy conditions continued for the next two days but about 5 o'clock the afternoon of the 12th the wind shifted to the westward during a rain squall and the blanket of fog was swept away. We were not slow to take advantage of such ideal conditions and for the next 36 hours conducted a search which led as far north as the 43° 30′ parallel. There were four bergs found in the searched area, the southernmost one on the forty-third parallel in the heart of the Labrador current drifting south-southwest at the rate of 0.8 knots per hour.

The scouting work on the 14th instant revealed more ice than the patrol had found heretofore this year. There were a total of 21 bergs found south of latitude 44° 15′ which was fartherest north for the trip. This ice was strung out along the eastern edge of the Bank and in positions which indicated that the bergs were tending to set on shore and strand. Many of the bergs had growlers near them and it was observed, moreover, that there were no extraordinary large bergs sighted. The rate of drift was estimated at 1.1 knots per hour.

Fog shut in again on the 15th and lasted with occasional brief "light ups" until May 20. During this time the *Modoc* steamed over an area lying off the southwest slope and around the Tail where a total of 12 stations of salinity and temperature were occupied A current map was constructed upon the basis of these data and the

bergs which had been lost in the fog were thought to have drifted either up on the southwest slope of the Bank or to the northeast in the counterset. In any event the current map showed that there was very little likelihood to suppose that the ice had been transported southward in the fog toward the steamship lanes.

Late in the afternoon of the 20th the steamer *Tiger* sighted 20 bergs off the Tail about 30 miles and so during the night we shaped a course so as to be in an advantageous position to commence searching at daylight on the 21st. During the next two or three days the patrol searched this entire area and plotted the positions of a total of 20 bergs and three growlers. As this discussion with sketches is taken up on page 65, it will not be entered upon here. On the 23d it was observed that the bergs farthest offshore to the southeast were slowly being turned in the current and were beginning a counter drift to the northeast. Later in the morning the *Modoc* laid a course to the southward and westward because no chances wished to be taken on bergs drifting unawares in that dangerous direction. While we were steaming in this quarter a fog bank rolled in completely enveloping the ice infested waters.

The approach of the *Tampa* returning for a new tour of duty was announced by radio the night of the 23d and so we headed over to the westward, meeting at a rendezvous about 100 miles west of the Tail. The *Modoc* received 67 reports of ice sighted by passing vessels, furnished ice information to 10 ships, requested acknowledgment from 22 vessels for the regular ice broadcast, and received 775 surface temperature reports during the cruise thus terminated.

THE FIFTH CRUISE, "TAMPA," MAY 25 TO JUNE 10, 1926

After relieving the *Modoc* the *Tampa* stood eastward toward the group of bergs last seen by the *Modoc* on the 23d instant but fog shut in the morning of the 26th causing us to drift until the arrival of clear weather again. Sometime during the morning we received a radio from the steamer *Clearpool* reporting a berg and growler in latitude 41° 49′, longitude 50° 12′. We immediately requested the master of the *Clearpool* to verify his position and indicate how recently he had obtained astronomical sights, because this position was considered surprisingly far south for any berg to drift so quickly. The reply stated that the previous position was in error and gave the latitude as 42° 24′. The *Tampa* got under way and had not proceeded very far when a growler was sighted close aboard in the fog. This we thought might be the same growler that the *Clearpool* had seen earlier in the day, so taking it as a point of departure we headed eastward about 10 miles where a berg was found. When the fog cleared later on we beheld five bergs in sight to the eastward, and so we steamed over to the largest one. This group of bergs was

undoubtedly part of the same ice which the *Modoc* located to the northeastward on the last cruise.

The fog cleared up for good on the morning of the 27th and gave us an opportunity not only to locate all the bergs in this region south of the Tail but also permitted of securing accurate sights. We had been without a definite fix of the ship's position for nearly four days. Ten bergs were sighted during the day, five in the dead water directly south of the Tail, latitude 42° 27′; two lay to the westward on about the same parallel but in longitude 51°; and three more bergs were observed grouped together at the farthest point south for the year, viz, latitude 42° 13′ longitude 50° 29′. The distribution of this last lot was in agreement with the oceanic circulation as determined May 18–20 by the *Modoc*. The bergs in longitude 51° 00′ had drifted as far west as was possible on account of the counterset in that region, while the three southern ones had become caught in the inshore edge of the easterly flowing water and they were drifting east-southeastward at the rate of 0.5 of a knot per hour.

On May 28 a message was received from the steamship *Chicago* reporting a berg in latitude 41° 51′, longitude 48° 33′; this being the southernmost ice and only about 20 miles north of the west-bound steamer track, the *Tampa* was headed on an easterly course in order to get in touch with this ice as soon as possible. At daylight on the 29th we sighted the berg for which we were in search. It was not a very large berg, in fact it was medium to small and it showed signs of rapid disintegration. During the morning and afternoon demolition operations were carried on, making use of 6-pounder gun and 238-pound TNT mines. Considerable ice was shaken down but it is questionable whether the expenditure would be justifiable in continuing such a practice on a greater scale. That evening we spent close to the ice warning all approaching ships of its location.

The next day our berg was only about half of its former size. The rapid disintegration was due without doubt to a heavy swell which continually washed the ice and broke off growlers one after another. The temperature of the water, 56°, of course also materially assisted to speed up the melting processes, and so May 31 witnessed the entire removal of this menace to navigation. This was the most rapid disintegration of which the patrol has record, to the best of our knowledge, and it is of interest because it was due in a great measure to the swell and sea which continually lashed and strained the berg. At 12.30 p. m. there was no longer any reason for remaining in the locality—latitude 40° 45′, longitude 47° 38′—so we steamed ahead on course 310° toward the group of five bergs which we had left on the 28th instant.

About 7 o'clock the morning of June 1 the steamer *Stadsdijk* reported seeing two bergs about 30 miles to the westward of where we were searching and this ice was believed to be the same that we

wished to sight. The course was accordingly changed for this new position and at the same time radiocompass bearings were taken of the *Stadsdijk.* While we were maneuvering to get in touch with this ice a message was received from the steamship *George Washington* that she had just passed a small berg about 35 miles to the eastward of where we were then and on the westbound steamer track. We immediately headed that way, made contact with the *Washington* at 11 o'clock, and picked up the berg just before sunset.

The *Tampa* remained close to this berg during the next four days, as long as it continued to be a menace to navigation. During the nighttime it was our practice upon the approach of steamers to throw the searchlight beam on the ice clearly marking its position. That this was appreciated is shown by the following message from the steamship *Mauretania,* which passed close to the *Tampa* one night. "We are passing south of you; can see berg in your searchlight beam. Thank you. Rostron."

A dispatch on June 2 broadcasted from Arlington radio station stated that the trans-Atlantic track conference had decided to change from tracks B to tracks A immediately, the eastbound track being moved June 2 to 39° 30′ latitude, and the westbound track being moved simultaneously to latitude 41°, with the complete shift of the westbound to latitude 40° 30′ on the 9th instant.

On June 4, with the melting of the aforementioned berg, the patrol vessel shifted its position 4 miles to the northward near a large berg which had been sighted the previous day. A survey was made of the exposed surface above water; a tower, the highest point on one end, measured 55 feet; the opposite end, 35 feet; and the length was 382 feet. It is worth mentioning here that the heights of bergs can be measured quite accurately by climbing the mast to a point where the line of sight of the observer passes tangent to the summit of the ice and through the horizon. A correction of 4 feet should be added to this as the correction for the dip of the horizon. Measured heights from the water line can be easily marked upon the mast in units of 5 feet, and it will seldom be found that heights of bergs will exceed the height of the crow's nest.

While the *Tampa* was lying alongside of this ice on June 5 the steamer *Leviathan* passed close aboard about 9 o'clock in the morning. She thanked the patrol for its services and very complimentary added, "Your vigilance was an inspiring sight to everybody on board. Hartley." Captain Fisher replied, "Glad to be of service to the queen of the American merchant marine. Your passing ship was an inspiring and beautiful sight." The early morning hours of June 6 witnessed the complete melting of this ice.

The last few days of the *Tampa's* cruise were spent patrolling along the southern boundary of the fog wall as it was impossible to carry on any ice scouting in the cold waters to the northward. The

Tampa received a total of 970 sea water temperatures from passing vessels; gave special ice information to 10 ships; and received a total of 159 reports of ice. There were 71 ships during the cruise from which we requested acknowledgment of receipt of the ice broadcast.

THE SIXTH CRUISE, "MODOC," JUNE 10 TO 25, 1926

The 11th and 12th were foggy days but June 13 it cleared and the *Modoc* was headed westward in order to get into an advantageous position for searching for any ice south of the Tail of the Bank. Excellent visibility prevailed on the 14th and the *Modoc* for the second day of clear weather was cruised at forced draft over a large area where bergs were suspected. No ice was found, however, and this fact was interpreted as indicating a great dwindling in the number of bergs from the high point earlier in the month. Not over three weeks previously in this same locality there were drifting more than 20 icebergs. A few reports continued to be received from steamers on the Cape Race tracks to the northward.

The 15th of June the *Modoc* spent searching from a point 70 miles west of the Tail along the forty-third parallel to the eastward about 90 miles. No ice was sighted and excellent visibility prevailed the entire day except for a short time in the afternoon. When we attempted to search northward, however, along the eastern slope of the Bank a wall of fog was met. The water along the slope, with a temperature of 46°, was 4° or 5° cooler than any other part of the surrounding surface water.

During the morning of the 16th we made another attempt to search northward along the east edge of the Bank but a heavy fog wall was soon entered which of course precluded all hopes of further ice search. The afternoon and evening were spent occupying a line of oceanographic stations extending south of the Tail, but this work had to be abandoned late at night due to a severe southerly storm and sea.

The storm ended on the 17th as suddenly as it had begun so we were quick to take advantage of the clear visibility searching northward as far as latitude 44° 30′ in the icy current. No ice was found in the current and this was taken as a very hopeful sign that there would be very few bergs able to drift as far as the Tail during the rest of 1926. A small berg was reported well to the northwestward on the southwest part of Bank, however, but its position was not dangerous, and it was believed this ice was the same as that reported on the 13th instant to the patrol, then grounded on the Tail.

We were able to continue the patrol's search on the 18th still farther to the northward, no bergs being found south of parallel 44° 45′. We anchored on the eastern side of the Bank on the 19th and 20th. The steamer *United States* sighted a small berg southeast of the Tail about 20 miles on the 19th but inasmuch as it was not

much larger than a growler in size and that it was floating in warm water, temperature 55°, it was not regarded as a potential menace. We searched this vicinity on the 22d, however, the first opportunity of clear weather but nothing was found so the *Modoc* was headed westward for a rendezvous with the relief ship.

There were 144 reports of ice received from passing vessels; 3 steamers were furnished special ice information upon request; and a total of 1,002 reports of surface water temperatures were received.

THE SEVENTH CRUISE, "TAMPA," JUNE 25 TO 30, 1926

After taking over the patrol work from the *Modoc* it was decided best to utilize the time compiling an ocean current map of the region around the Tail of the Bank, in order that a record might be made of the current conditions just before the patrol was discontinued. Stations were occupied along lines normal to the trend of the slope and spaced at intervals of 50 to 75 miles.

This work continued and the 26th found the *Tampa* running northward on a line just south of the Tail. The water temperature wall was found to lie in latitude 41° 55′, longitude 50° 15′, the thermometer dropping from 61° to 57° quite abruptly. The position of the temperature wall at this place refutes the belief that the position of the Atlantic water had been changed much from that found earlier in the season. Such an error of judgment is easily made because of the relatively high temperature of the surface water which is attained solely as an effect of the sun's heat with the approach of summer.

The 27th, 28th, and 29th were spent on oceanographic survey and when the weather was clear advantage was taken to include a search for ice. Not a sign of bergs was found and so a recommendation was forwarded to headquarters that the patrol be discontinued at midnight on June 30. A reply the next day directed the patrol to discontinue its activities at midnight June 30 and return to the United States.

We headed westward on the last day of the month preparatory to returning to Boston. No ice had been reported or sighted by the patrol vessel south of the forty-fourth parallel since June 17 and this area had been repeatedly searched since that date. We were quite confident that no ice could possibly be in these waters. Bergs continued to be reported on the northern part of the Bank and near Cape Race as is usually the case at this time of the year. Messages were dispatched to the wireless officer, Halifax; the officer in charge radiocompass station, Cape Race; and the commercial wireless station, Cape Race, notifying them all of the discontinuation of the ice patrol and thanking them for cooperation during the 1926 season.

During the cruise thus terminated the *Tampa* received 36 reports of ice, furnished special ice information upon request to 1 steamship, and received a total of 186 sea-water temperature reports.

RADIO COMMUNICATIONS

The vital importance of the radio to the plan of an ice patrol warning approaching ships of the dangers in their paths is quite obvious. It would be literally impossible to perform this humanitarian service if it were not for Marconi's pioneer invention. Naturally the efficiency and value of the patrol, as it proportionately assists to increase the safety of life on the North Atlantic, is closely wrapped up in the entire subject of radio. Not only is it the ice which is actually found by the patrol that is reported to shipping, but also is included the ice from a much larger area than that which the patrol could possibly hope to cover. Such accomplishments can only be realized with the cooperative assistance received from passing ships which report to the patrol from positions scattered over the entire danger region. It can be seen that under such circumstances the patrol vessel assumes the rôle of a radio clearing house and thus becomes the disseminator of a digested report for the whole region. The story of the past season's work, as in former years, has been one of willing and efficient service on the part of the merchant vessels. We also want to add that the Canadian direction-finding stations and the Cape Race Commercial Radio Station have done everything possible to make the radio operations run smoothly and successfully. The summary of the work performed during the 1926 season will be found in the report of the ice patrol commander, page 17.

A survey of the radio communications during 1926 particularly impresses us with a feature which excels previous years; and the part we have in mind refers to the great improvement regarding the ship to shore communication. The patrol, in its early years, depended upon forwarding its traffic to Washington via the nearest coastal station, Cape Race, Newfoundland, by means of an ordinary 2-kilowatt spark transmitter. There were, however, times during the first few weeks of the ice season, say until April 1, when direct communication was possible by this means, but for the major part of the season, it was necessary to transmit messages via Cape Race.

Because of the expensive tariffs by this route it has long been the desire to establish official communication between the patrol and naval radio stations situated in the United States. When the then new ships *Tampa* and *Modoc*, in 1922, were assigned to patrol duty, more frequent communication with United States coastal stations was effected by means of arc sets with which these vessels were

equipped. This service failed quite often, however, due to summer time static conditions and poor functioning of the sets. Such unsatisfactory conditions caused the officials in charge of the patrol work in 1925 to equip the ships with 2-kilowatt vacuum tube transmitters, especially designed and manufactured by the General Electric Co. (See Ice Patrol Bull. No. 13, p. 51.) Communication by means of these sets with the naval coastal station at Bar Harbor, Me., was more reliable and satisfactory than at any time during patrol history. Summer time static conditions even then, quite frequently in June, necessitated an auxiliary service, communication being effected via the patrol ship off duty in Halifax. Realizing the natural difficulties which the patrol had met for several years with ship-to-shore traffic, a new type of set was installed just before the ships sailed in 1926. This set employs a short-wave, high-frequency transmitter, 35 or 70 meters, and it represents a new design which the United States Navy is manufacturing. In fact the work was rushed in order that the patrol might be equipped for 1926. During the first half of the season minor alterations were found necessary before the best performance was attained, but by the latter part of the patrol the sets were operating satisfactory. Direct communication with the high-frequency sets was maintained with few exceptions the entire patrol of 1926 with the Navy Experimental Laboratory, Bellevue, Md. The set is described as a Navy model "XA," 500-watt crystal control, with a frequency of 4,205 and 8,410 kilocycles, and was manufactured at the laboratory, Bellevue.

The other radio equipment carried on board the ice patrol vessels was the same as that in use during the 1925 patrol. (See Ice Patrol Bull. No. 13, pp. 51–52.) Information regarding the weather was broadcasted every night and morning by means of the 2-kilowatt tube transmitter (C. G. model T–2). Also information of a general character as to the behavior and distribution of ice and currents were "talked" quite informally this past year as the steamers approached the ice regions. The officers of these vessels were especially invited to come to the radio room and listen in and it was apparent that these phone talks were of considerable value. It is human to forget with the passage of time even the lessons learned through great tragedies, and the mariner is no exception to this rule. It is, we believe, part of the spirit of ice patrol, to educate by talks on the entire subject of this danger every spring. The patrol has trained experts and it is certain that their knowledge will be of interest and stimulate educational thought along similar lines with the navigator.

The amount of ice patrol traffic handled by radio is always interesting and indicative of the amount of work performed by that means. There were approximately 5,488 reports received from pass-

ing steamers concerning their position, course, speed, and sea water temperature. A total of 470 official messages were transmitted to Washington, and 236 were received. It is estimated that a total of 252,299 words were handled during the season of 1926. (See p. 20.)

There is appended herewith a schedule giving the times at which messages were sent and received by the patrol vessel. The schedule was not adopted until after several preliminary experiments and trials, so that the final draft as outlined here ought to furnish a very good schedule upon which to base radio operations for next year.

(All times seventy-fifth meridian)

0600. Ice broadcast (spark); call on 600 meters then send on 706 meters twice with a two-minute interval.

0700. Ice broadcast (continuous wave); call on 600 meters then send twice on 1,713 meters with two-minute interval.

0800. Send weather report to Bar Harbor, Me., on 1,713 meters, using "no answer" method.

0915. Copy Cape Race weather broadcast.

1030. Copy Arlington weather broadcast.

1200. Copy time signals and ice patrol traffic from Arlington.

1415. Copy weather broadcast from Cape Race.

1800. Ice broadcast (spark); call on 600 meters then send on 706 meters twice with two-minute interval.

1900. Ice broadcast (continuous wave); call on 600 meters then send on 1,713 meters with a two-minute interval.

1930. Clear all ship to shore traffic with Navy Experimental Laboratory, Bellevue, Md., on 35 meters.

2000. Stand-by schedule with Bar Harbor, Me., on 1,713 meters only in case the 1,930 schedule fails.

2115. Copy Cape Race weather broadcast.

2200. Copy time signals and any ice patrol traffic from Arlington.

2230. Copy weather broadcast from Arlington.

SUMMARY REPORT OF ICE PATROL COMMANDER

Commander H. G. Fisher, Commander International Ice Patrol

Ice patrol was inaugurated March 25, when the *Tampa* sailed from Boston for the Grand Banks. The *Modoc* departed from New York in sufficient time to relieve the *Tampa* on April 11, and thereafter these two ships took alternate 15-day tours of duty throughout the ice season. The patrol was discontinued at midnight June 30, having been on guard a total of 97 days.

The ice patrol which is now 13 years of age, has during this period had opportunity to study its problems, and plan its general administration so that now many of the features of the work have become systematized, especially those events which have gradually grown to assume a more or less routine character. The work, as has often been remarked, possesses two main aspects—(*a*) the practical and (*b*) the theoretical. The first (*a*) embraces the primary function of locating by actual scouting and radio communication, the icebergs and field ice nearest to and menacing the North Atlantic lane routes, and the duty of placing that information at the disposal of all approaching trans-Atlantic ships. The second (*b*) centers on carrying out an intelligent scientific program the results of which throw light of practical importance on the economic humanitarian service which the patrol endeavors to render to shipping.

In speaking of the practical work it is customary to include in the summary report of each year a brief review of the distribution of ice in time and place, its drift, numbers of bergs, and a survey of the weather which has been experienced during the season. It may be quite confidently stated that less field ice drifted south of Newfoundland in 1926 than usual. In fact there were very few reports of field ice before the month of March with the flat ice attaining a maximum early in April, and with the last report dated May 11. Even at the date of its most southern extension, April 4 and 5, it did not reach as far as the Tail of the Bank, nor did it spread to any great extent over the Grand Banks south of Newfoundland as it often does. It held, however, more or less closely to the eastern and northern portions of the Grand Bank as usual.

Ice conditions in the Gulf of St. Lawrence this year were very open, the patrol receiving a message from the Canadian ice patrol ship *Mikula* that the gulf and river were navigable to Quebec on April 18, or about one month earlier than usual.

The first icebergs were reported south of Newfoundland in February; the number increased in March. No bergs drifted south of the Tail during April; few during the first half of May; but the latter half of that month saw the greatest number of bergs for the season. After June 6 no bergs of any size drifted south of the Bank. The total number of bergs drifting south of Newfoundland during 1926 was nearly normal but the seasonal distribution was not. (See p. 72.) Three bergs drifted much farther south than the others, crossing the westbound steamship lane route, known as track B. Due to the presence of this ice in such menacing positions the tracks were shifted to A, 60 miles farther south from June 5 to 30. As previously stated there were reports of only two bergs of any consequence in June around the Tail of the Bank, one on the 12th and the other on the 17th. The last two weeks of that month these waters were free of ice and under such conditions consequently it was considered safe to discontinue the patrol on June 30.

A considerable number of bergs, it should be added, were reported on the northern part of the Bank, from May on throughout the ice season.

The patrol was treated to an unusually long rough spell of weather persisting to the latter part of April before the backbone of winter was finally broken. This agrees quite closely with the seasonal change to the westward over the United States when winter conditions prevailed unusually late into the spring of 1926. Winter atmospheric circulation of the ice regions differs quite markedly from summer time conditions. The Grand Banks south of Newfoundland are located on the southern side of a cyclonic wind system caused by the normal winter distribution of atmospheric pressures. The barometric gradients are exceedingly steep, causing westerly gales to blow with great and constant intensity for several days at a time, though they are often interrupted by low centers of marked disturbance, moving along a northeasterly track to die offshore in the Atlantic. It can be imagined that under such severe handicaps as prevailed this year, March 25 to April 22, little work of any value could be carried on. By the same token it is considered unwise in any year to inaugurate the patrol work so long as winter conditions persist.

The scientific work carried on this season was under the supervision of Lieutenant Commander Smith, who returned to the patrol after spending a year abroad on two of the most important natural problems which have for some time confronted us, viz (*a*) information regarding the probable drift of ice after arriving at the Tail of the Grand Banks, and (*b*) advance information about the annual amount of ice to be expected south of Newfoundland. The former subject is discussed under the section devoted to oceanography; the latter is taken up under the heading "Weather."

A notable advance in this year's work was the employment of dynamic methods to determine and map the currents around the Grand Banks. A special bulletin, No. 14, describing the work for use on ice patrol, has recently been published by the Coast Guard. The final answer as to the degree of success attending it depends on its practical employment on future ice patrols. It would be very wise and advisable if officers of the Coast Guard detailed to patrol duty were required to acquaint themselves with these methods in order that several may possess this knowledge instead of only one officer, as is now the case. The international ice patrol will give its most efficient and economic service to shipping only when useful scientific methods are employed to support the practical work.

The patrol ships were equipped this year with practically the same outfits as they had on board in 1925, with the exception of new high-frequency radio sets, especially intended for use in communication with shore, and a second electric salinity set so that determinations might be made on board both ships instead of on one alone, as in previous seasons. The performance of the new radio sets for ship-to-shore communication, as stated in more detail under the section devoted to communications, page 14, well repaid the expense and effort expended in placing the apparatus on board.

About 465 hydrographical soundings by means of the sonic apparatus were made during the season at various positions both in the shallow waters over the Grand Bank and offshore, particularly to the southward of the Bank in the deeper portions of the Atlantic Basin. These are described under the section devoted to sonic sounding, page 49. The value of carrying on this work on future patrols is emphasized, and in this connection it is believed that both ice patrol vessels ought to be equipped with sonic depth apparatus instead of one, as is now the case; steps also ought to be taken to have at all times at least one trained operator on board.

About 450 steamships are known to have taken advantage of the services offered by the ice patrol in 1926. No doubt several other ships of which there is no mention also listened-in for the daily broadcasts. The following list is submitted in order that the reader may gain an idea of the service which is being given the ships of many nationalities. The masters of these vessels have been individually thanked, by letter, by the chairman of the interdepartmental board in charge of ice patrol.

Belgian	8	Danish	8	Greek	1	Argentian	1
British	171	Dutch	25	Italian	9	Spanish	5
Canadian	27	French	13	Japanese	1	Swedish	11
Chilean	1	German	14	Norwegian	20	United States	114

A summary of work performed, the dissemination of information, and other miscellaneous business handled by the Patrol for 1926 follows:

Washington official messages	470
Daily routine broadcasts	372
Special broadcasts (during fog)	42
Ice information to certain vessels, special	165
Special ice information requested	48
Position reports requested	1
Track information requested	4
Chronometer comparisons	1
Weather reports	102
Water temperature reports received	5,488
Ice reports received from:	
Steamships	414
Cape Race	172
Words handled by radio	252,299
Violation of steamship tracks reported	1
S O S not in jurisdiction of Patrol vessels	4

As in previous years, the cooperation received from passing ships was generous and indicative of a sincere appreciation of this service, which is being financially supported by international contribution. The commander of the ice patrol takes this opportunity to thank all those who assisted to make the past season's work successful.

TABLE OF ICE AND OF OTHER OBSTRUCTIONS, 1926

Date	No.	Vessel reporting	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Feb. 8	1	Cape Race (station)	48 11	49 13	Slush ice.
10	2	do	48 15	49 40	Field ice east of St. Johns.
10	3	do	47 25 to 47 08	49 50 to 51 05	Occasional patches field ice.
10	4	do	44 53	59 52	Field ice.
15	5	do	Bull Head to Canso.		Do.
16	6	do	100 miles NE. Cape Race.		Do.
17	7	do	Along the coast		Heavy ice field.
19	8	do	44 46 to 44 40	58 57 to 60 28	Do.
20	9	do	48 09 to 48 06	48 07 to 49 20	Do.
20	10	do	47 50	50 04	Slab ice and small bergs.
21	11	do	45 15	59 44	Field ice.
21	12	do	47 17	47 03	Several small bergs.
22	13	do	41 04	37 40	Derelict schooner Cecil jr.
Mar. 2	14	do	48 16 to 47 40	46 50 to 47 50	Small bergs and growlers.
2	15	do	45 07 to 45 05	57 13 to 57 42	Field ice.
6	16	do	48 24	46 22	Do.
15	17	do	47 50	49 38	Field ice and occasional bergs.
16	18	do	47 24	50 57	Field ice.
18	19	do	47 54 to 46 57	47 58 to 48 45	Heavy field ice and small bergs.
19	20	do	46 56	47 49	Field ice and growlers.
19	21	do	45 00 to 45 30	58 20 to 57 40	Field ice.
19	22	do	45 40 to 46 05	47 00 to 46 25	Field ice and large growlers.
20	23	do	46 20 to 45 40	46 40 to 48 30	Do.
20	24	do	45 38	46 23	Small bergs.
20	25	do	45 41	46 03	1 berg.
20	26	do	46 20 to 45 40	46 40 to 48 30	Field ice and growlers.
20	27	do	45 10	46 30	Large bergs.
20	28	do	45 15	46 45	Small berg.
20	29	do	45 16	47 29	Large berg.
20	30	do	45 17	47 46	Do.
20	31	do	45 09	48 35	Do.
21	32	do	44 55	46 23	Growlers.
21	33	do	44 50	48 30	Numerous growlers; field ice.
22	34	do	44 35	57 20	Field ice.
22	35	do	44 22	48 36	Field ice and growlers.
22	36	do	44 18	48 36	Small berg.
20	37	Hydrographic Office	45 17	46 30	4 large bergs.
20	38	do	45 30	48 10	3 bergs.
21	39	do	45 15	48 10	Large ice field.
23	40	Naturia	48 10	48 00	Large ice field; growlers.
23	41	Cape Race (station)	48 20	49 15	Field ice.
23	42	do	43 47 to 43 43	48 28 to 48 41	Field ice and growlers.
25	43	do	43 45	48 07	Do.
25	44	do	48 45 to 48 00	49 20 to 48 00	Field ice.
25	45	do	45 50	47 20	Do.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Mar. 26	46	Cape Race (station)	42 51	58 04	Spar attached to wreckage.
27	47	do	47 00	48 00	Large bergs.
27	48	do	44 20	49 10	Large growlers.
27	49	Baltic	49 10 to 47 31	49 23 to 46 34	Large ice field.
29	50	Noresfjord	47 33	46 23	Field ice and growlers.
29	51	do	46 40	47 24	Large berg.
29	52	Dakarian	40 32	47 36	Derelict schooner Max Horton on fire.
31	52*a*	Laleham	39 05	56 37	Foundered steamer Laleham.
Apr. 1	53	Cape Race	44 42	57 15	Heavy ice field.
2	54	Helig Olav	45 11	45 00	Ice berg.
2	55	Cape Race (station)	47 47	52 05	Ice field.
2	56	do	47 20	52 09	Do.
3	57	London Exchange	46 15 to 45 00	47 35 to 48 50	Field ice and growlers.
3	58	Cape Race (station)	42 43	55 40	Spar attached to wreckage.
4	59	Ice patrol	43 59	48 55	Field ice, southern extremity.
5	60	do	43 33	49 12	Same as 59; drifting 190°, 1 knot.
5	61	do	42 23	49 12	Same as 59; drifting 180°, 1 knot.
6	62	Tampa (steamer)	45 32 to 46 32	48 20 to 47 36	Field ice and growlers.
8	63	Sulina	44 00	48 10	3 small bergs.
9	64	Ice patrol	44 10	47 54	Same as 63; drifting 49°, 0.7 knot.
10	65	Manchester Corporation	44 55	46 52	1 iceberg.
10	66	Carlsholm	46 55	47 25	Field ice.
11	67	do	46 45	48 00	Western side of ice field, same as 66.
12	68	Alaunia	44 43	60 32	Field ice (St. Lawrence).
13	69	do	44 44	60 26	Do.
13	70	City of Kimberly	44 44	59 10	Do.
14	71	Alaunia	44 04	56 47	Do.
14	72	Cameronia	46 58	46 30	Do.
14	73	do	47 01	45 16	4 bergs and growlers.
14	74	Bellflower	45 05	46 34	1 berg, 2 growlers.
16	75	London Mariner	44 32	45 16	Small berg.
16	76	Transylvania	46 25 to 45 58	47 00 to 47 45	Field ice and growlers.
16	77	Regina	46 34	47 54	1 berg, 2 growlers.
16	78	do	46 27	47 47	1 berg.
16	79	Transylvania	45 42	48 15	1 large berg.
16	80	do	45 57	47 45	2 growlers.
16	81	do	46 05	47 22	1 growler.
16	82	do	45 48	47 42	Low lying ice field.
17	83	Bergensfjord	45 40	45 25	3 growlers.
17	84	do	45 39	45 28	1 growler.
17	85	Lorenz Hansen	39 39	55 26	Deck load of spars.
17	86	Cedarhurst	39 46	57 45	Sea covered with wreckage.
20	87	Idefjord	46 55	45 45	2 small bergs same as 73.
20	88	Terra Nova	47 10	51 00	Western edge field ice.
21	89	Athenia	45 52	47 57	Large berg, same as 77.
21	90	Aurania	47 40	46 15	1 berg.
21	91	do	47 16 to 47 14	47 10 to 47 20	Field ice.
21	92	Montnairn	46 46	45 39	Small berg, same as 73.
21	93	Ansonia	45 53	45 12	Do.
21	94	Aurania	47 00	48 00	1 berg.
22	95	Doric	47 40	46 21	Low lying berg.
22	96	Station Belle Isle	------	------	84 bergs in sight; field ice.
22	97	Caronia	47 35	46 11	Small berg, same as 95.
22	98	do	47 28	46 28	Small berg.
22	99	do	47 27	46 35	Do.
22	100	do	47 14	46 47	Small berg and growlers.
22	101	do	47 09	47 00	20 bergs in heavy pack ice.
22	102	do	46 52	46 48	Field ice, same as 88.
22	103	Montrose	47 38	44 40	1 growler.
22	104	Caronia	46 10	48 11	1 small berg.
23	105	Bothwell	47 02	45 47	Large berg.
23	106	do	46 27	47 06	Southern end field ice; seven bergs.
23	107	Twickenham	48 28	48 29	Heavy field ice.
24	108	Cairntorr	48 25	47 10	Do.
24	109	Geraldine Mary	47 13	47 42	Field ice.
24	110	do	47 13	50 52	Berg.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north ° ′	Position: Longitude, west ° ′	Nature of ice or obstruction
Apr. 24	111	Geraldine Mary	46 58	46 48	Field ice.
24	112	Wirral	47 00	44 40	2 bergs.
24	113	Blackheath	48 16	47 10	Scattered field ice.
24	114	Arabic	47 36	43 49	Small berg, same as 112.
24	115	do	47 05	44 41	Do.
24	116	Cairntorr	48 25 to 47 49	46 30 to 46 40	Slob ice.
24	117	Maidenhead	46 11	48 48	Large berg.
26	118	Cairntorr	46 45	47 30	Heavy field ice; numerous bergs.
26	119	do	47 49 to 47 05	46 40 to 47 25	Open field ice; several bergs.
26	120	do	47 05 to 46 49	47 25 to 47 14	Heavy field ice; many bergs.
26	121	do	46 32	47 45	Western edge of field ice.
27	122	Unknown ship	47 08	46 18	Large berg, same as 101.
27	123	do	47 07	46 34	Growlers, same as 101.
27	124	do	47 06	46 32	Do.
27	125	do	47 10 to 45 56	46 44 to 47 35	Heavy field ice; numerous bergs.
27	126	do	45 57	47 37	Large berg.
27	127	Minnedosa	47 10	46 03	5 growlers, same as 101.
27	128	do	47 12	46 19	Berg, same as 122.
27	129	do	47 03	46 30	Large ice field with many bergs, same as 101.
28	130	Transylvania	44 48	48 41	Small berg and growlers.
28	131	Minnedosa	45 48 to 45 33	47 00 to 47 24	Patches of slob ice.
28	132	Bawtry	45 50	47 22	Berg; patches field ice, same as 131.
29	133	Montcalm	47 34 to 47 04	46 39	Patches of field ice.
29	134	do	47 00	46 52	Berg, same as 101.
29	135	do	46 50	47 06	3 bergs, same as 101.
29	136	Drottingholm	44 47	48 39	Small berg and growler, same as 130.
29	137	do	44 32	48 48	Large berg.
29	138	Zeeland	45 03	48 05	Do.
29	139	do	44 35	48 25	Do.
29	140	do	44 52	48 32	Small berg, same as 136.
29	141	do	44 18	48 46	Large berg, several growlers.
29	142	do	44 32	48 58	Large berg, several growlers, same as 137.
29	143	Valemore	45 29 to 45 29	47 45 to 48 02	Southern end of ice field.
29	144	do	45 29	48 21	Low lying ice berg.
29	145	Canadian Commander	45 28	48 03	An ice field.
29	146	Modig	48 33 to 48 58	45 35 to 49 30	Patches of field ice.
May 1	147	Frode	45 25	48 31	Berg.
2	148	Roussillon	44 10	48 30	Do.
2	149	Suderoy	46 09	46 24	Field ice.
3	150	Brandon	45 20	46 03	Skirting southern end ice field.
3	151	Lord Downshire	47 03	47 15	2 bergs.
3	152	Montairn	44 50	48 13	3 growlers.
4	153	Athenic	45 47	46 31	1 berg.
5	154	Doric	46 22	47 53	Field ice.
5	155	Thuban	45 50	48 00	Much field ice and small bergs.
5	156	Welshman	45 47	46 59	2 growlers.
5	157	Empress of France	46 38	47 25	Scattered field ice, same as 154.
6	158	Regina	48 07	43 34	Western edge field ice.
7	159	Winterswijk	45 50	46 20	Large growler.
7	160	Athenia	45 51 to 44 35	48 50 to 48 45	3 bergs, several growlers.
8	161	Winterswijk	44 35	48 45	Field ice.
8	162	Ansonia	44 48	48 46	2 bergs, same as 160.
8	163	do	44 47	48 45	Western ice.
8	164	Procyon	47 20 to 47 23	46 29 to 47 30	Many bergs and growlers.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north (° ′)	Position: Longitude, west (° ′)	Nature of ice or obstruction
May 8	165	Ansonia	45 02	49 18	Growlers.
8	166	Letitia	44 38	48 51	Berg.
8	167	do	44 54	48 46	Do.
8	168	do	44 55	48 38	Do.
8	169	Montrose	47 00	47 25	Heavy ice field.
8	170	Ansonia	44 55	46 00	Berg and 2 growlers.
9	171	Letitia	44 51	46 51	Berg.
9	172	Tyrifjord	45 07 to 45 00	47 51 to 48 36	3 bergs, same as 166 to 168.
9	173	Minnedosa	45 45	49 51	Small berg and growler.
9	174	do	45 47	49 49	1 berg.
10	175	Berk	44 27	46 31	2 bergs and ice field.
10	176	do	44 21	46 44	Berg.
11	177	Sheafbrook	46 40	56 10	Derelict bottom up.
12	178	Canada	45 31	49 49	Small berg, same as 173.
12	179	Melita	46 12	48 40	Large berg.
12	180	California	44 15	48 30	Do.
12	181	Montroyal	45 58	48 28	Berg.
12	182	Cairndhu	45 37	48 00	1 berg, 13 growlers.
12	183	California	44 15	48 56	Large growler.
12	184	Cairndhu	45 38	49 00	Berg.
12	185	Lenfield	45 03	49 09	Do.
12	186	Cairndhu	45 38	49 20	Do.
12	187	do	45 38	49 37	2 bergs.
12	188	Marbarn	44 08	49 05	Large berg.
12	189	Alaunia	44 00	49 12	Low-lying berg.
13	190	Metagama	45 44	47 29	Large berg.
13	191	do	45 30	48 19	2 growlers.
13	192	Ice Patrol	43 01	49 33	Berg.
13	193	Cameronia	46 34	48 34	Do.
13	194	do	46 38	48 41	2 growlers.
13	195	do	46 21	48 52	Berg.
13	196	do	46 24	48 58	Do.
13	197	do	46 39	49 00	Do.
13	198	do	46 18	49 07	Do.
13	199	Searstad	47 50 to 47 50	48 20 to 47 30	Numerous bergs.
13	200	Marburn	46 42 to 46 34	46 55 to 47 06	Numerous bergs and growlers.
13	201	Delaware	39 32	50 47	Spar attached to wreckage.
13	202	Metagama	45 35	50 26	Berg.
13	203	Oxonion	46 00 to 46 00	50 02 to 49 00	Small bergs and growlers.
13	204	Ascania	47 17	47 00	Berg.
13	205	Cornish City	43 21	49 13	Low-lying berg.
13	206	do	43 21	49 02	Growlers.
13	207	Boswell	46 05	49 50	Berg.
13	208	do	45 50	49 50	Low-lying berg, same as 203.
13	209	Cameronia	46 12	49 24	Berg, same as 207.
13	210	do	46 05	49 22	Berg, duplicated.
13	211	do	45 59	49 16	Berg.
13	212	do	45 59	49 20	Berg, duplicated.
13	213	do	46 06	49 23	Do.
13	214	do	46 18	49 44	Do.
13	215	do	46 06	49 31	Do.
13	216	do	46 01	49 40	Do.
13	217	do	45 32	49 46	1 berg and growlers.
13	218	Mexico	43 30	49 10	Berg.
13	219	do	43 24	48 50	Do.
14	220	Ice patrol	43 05	49 15	Low-lying berg, same as 205.
14	221	do	43 10	49 26	Small berg.
14	222	do	43 23	49 29	Low berg.
14	223	Megantic	46 30	47 50	Berg.
14	224	do	46 47	47 40	Do.
14	225	do	46 32	48 18	Do.
14	226	Penland	45 46	49 31	Growlers.
14	227	Ascania	46 53	48 15	Berg.
14	228	Andersen	40 38	54 10	Spar attached to wreckage.
14	229	Ice patrol	44 00 to 43 35	49 10 to 49 19	17 bergs along edge of Bank.
14	230	Jean D'Arc	43 50 to 44 15	49 22 to 49 15	Ice field and several growlers.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 14	231	Brattingsborg	46 25	47 00	Field ice and small bergs.
15	232	Ice patrol	42 44	49 59	Same as 229.
15	233	Sunoco	46 48 to 46 00	46 36 to 49 50	Bergs continuously and growlers.
15	234	Brattingsborg	46 15	48 00	Numerous bergs, same as 233.
15	235	Ice patrol	42 47	49 50	Same as 232.
16	236	do	43 02	49 52	Same as 192, grounded berg on Tail.
16	237	Kapristan	45 02	50 00	Several small bergs and growlers.
16	238	Topdalsfjord	48 16	49 40	2 bergs.
16	239	do	48 07	46 56	1 berg.
16	240	do	48 03	50 08	2 bergs.
16	241	do	47 46	50 40	1 berg.
16	242	Kinghorn	49 02	49 30	3 bergs.
16	243	do	49 15	48 54	2 bergs.
16	244	Port Sydney	47 00	45 40	Slot ice.
16	245	Gracia	47 23	47 14	4 bergs.
17	246	do	46 07	49 44	Several bergs, same as 101.
17	247	Montclare	45 15 to 45 10	49 42 to 48 56	12 bergs.
19	248	Antonia	45 16	49 54	3 bergs, same as 247.
19	249	Lord Kelvin	47 14	46 35	Berg.
19	250	do	47 16	46 37	Do.
19	251	do	47 05	46 45	Large berg.
20	252	do	47 00	47 11	Do.
20	253	do	46 53	47 20	Berg.
20	254	Lord Kelvin	46 19	48 57	Large berg.
20	255	Empress of Scotland	47 48	48 09	2 bergs, 1 growler.
20	256	do	47 45	48 26	2 large bergs.
20	257	Welshman	48 22	46 16	Berg.
20	258	Tiger	43 04 to 43 02	49 20 to 49 20	10 bergs, several growlers.
20	259	do	43 03	49 41	Berg.
20	260	do	42 59	49 53	Do.
20	261	do	42 58	50 02	Do.
20	262	Moveria	46 06	48 45	Do.
20	263	do	46 09	48 56	Do.
20	264	do	46 14	48 25	Do.
20	265	do	46 36	47 40	Do.
20	266	Aalsum	44 00 to 44 00	49 02 to 48 26	3 bergs, several growlers.
21	267	Ice patrol	42 43	50 10	Berg, same as 258.
21	268	do	42 45	50 08	Do.
21	269	do	42 54	50 09	Do.
21	270	do	42 30	50 10	2 growlers, same as 258.
21	271	Empress of Scotland	47 34	49 15	Berg.
21	272	do	47 33	49 32	Do.
21	273	Arlington Court	47 48	48 13	2 bergs.
21	274	Tenbergen	46 29	46 22	Small berg.
21	275	do	46 26	46 45	Do.
21	276	do	46 17	46 50	Do.
21	277	do	46 22	46 50	Large berg.
21	278	do	46 17	47 35	Small berg.
21	279	Brecon	46 27	48 22	Berg.
21	280	do	46 23	48 26	Do.
21	281	do	46 11	48 51	Do.
22	282	Venus	46 27	50 13	Do.
22	283	do	47 32	49 56	Do.
22	284	Estonia	48 45	48 55	2 growlers.
22	285	do	48 46	47 57	Do.
22	286	Letitia	49 33	45 05	Berg.
22	287	do	49 24	45 05	Do.
22	288	do	49 23	45 26	Do.
22	289	do	49 22	45 25	Do.
22	290	do	49 25	43 35	Do.
22	291	do	49 16	45 36	Do.
22	292	Hastings County	48 45	48 47	Do.
22	293	do	49 08	47 47	Do.
22	294	Letitia	48 30	47 55	Do.
22	295	do	48 25	48 08	Do.
22	296	do	48 18	48 14	Do.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 22	297	Ice patrol	Around	Tail	26 bergs, scattered around Tail.
22	298	Letitia	49 33	45 05	Berg.
22	299	do	49 24	45 26	Do.
22	300	do	49 22	48 25	Do.
22	301	do	49 16	45 36	Do.
22	302	do	49 04	46 05	Do.
22	303	Manchester County	48 50	47 00	Do.
23	304	Metagama	47 22	50 01	Do.
23	305	do	47 29	49 59	Do.
24	306	Thyra	44 02	48 42	4 bergs.
24	307	Metagama	47 46	49 07	Berg.
24	308	Montrose	48 33	49 27	Do.
26	309	Cameronia	48 04	49 20	Berg, same as 297.
26	310	Clearpool	42 24	50 20	Growlers, same as 297.
26	311	do	42 24	50 20	Berg, same as 297.
26	312	Wanjasdga	42 42	50 01	Do.
26	313	do	42 51	50 00	Do.
26	314	Cameronia	48 55	47 23	Berg.
27	315	Ice patrol	42 15	50 32	A group of 5 bergs, same as 297.
27	316	do	42 34	51 05	Berg, same as report No. 297.
27	317	do	42 37	51 09	Do.
27	318	American Merchant	43 54	44 45	Berg.
27	319	Zeeland	48 04	47 27	Do.
27	320	California	48 14	44 44	Do.
27	321	do	47 34	46 21	Do.
27	322	do	47 25	47 00	Do.
27	323	Ansonia	48 38	44 50	Do.
27	324	do	48 25	46 25	Do.
27	325	do	48 28	46 20	Do.
28	326	Ice patrol	42 12	50 10	Group of 5 bergs, same as 315.
28	327	Chicago	41 51	48 33	Berg, probably same as 297.
28	328	Hamburg	41 48	48 26	Berg, same as 327.
28	329	Seattle Spirit	41 50	48 23	Do.
28	330	Inverurie	40 54	47 00	Small vessel bottom up.
29	331	Ice patrol	41 23	48 23	Berg, same as 327.
29	332	Western Plains	42 04	49 38	Berg, same as 315.
29	333	do	42 05	49 48	2 bergs, same as 315.
29	334	Unknown ship	45 00	47 50	4 bergs, 7 growlers.
29	335	Oscar II	42 28	50 19	Same as 297.
29	336	do	42 25	50 30	Do.
29	337	do	42 40	50 33	Do.
29	338	do	42 37	51 35	Same as 316.
29	339	do	42 39	51 36	Same as 317.
30	340	Ice patrol	40 56	47 56	Same as 327.
30	341	Empress of Scotland	48 15	45 14	Small berg.
30	342	Virginia	43 22	43 02	Berg, same as 318.
30	343	Cape Race (station)	48 23	50 38	3 bergs.
30	344	do	48 17	51 06	Berg.
30	345	do	48 19	51 50	Large berg and growlers.
30	346	do	48 22	46 57	Berg.
30	347	do	48 30	51 02	2 growlers.
30	348	do	48 27	51 06	Berg.
30	349	do	47 30	50 58	Large berg.
30	350	do	47 34	51 04	Berg.
30	351	do	48 03	50 08	5 bergs.
30	352	do	48 13	51 53	Berg, same as 345.
30	353	do	48 07	52 24	Berg.
30	354	do	48 09	52 15	Do.
30	355	do	48 20	51 23	Do.
30	356	do	47 24	51 28	Do.
31	357	Ice patrol	40 44	47 39	Growler, same as 327 (melted).
31	358	Quercus	44 24	46 52	2 bergs.
31	359	Letitia	47 39	50 33	Berg.
31	360	do	47 45	50 32	Do.
31	361	do	47 42	50 21	Berg and growlers.
31	362	do	47 53	50 04	Berg.
31	363	do	47 54	49 59	Do.
31	364	do	47 49	49 48	Do.
31	365	do	47 22	51 26	Growler.
31	366	do	47 38	51 07	Berg.
31	367	do	47 31	50 54	Do.
31	368	do	47 38	50 37	Do.
June 1	369	Stadisdyk	41 35	49 41	Berg (position probably northward).
1	370	do	41 36	50 12	Do.
1	371	George Washington	41 26	48 34	Small berg.
1	372	Winona County	41 53	50 15	Berg.
1	373	do	41 54	50 02	Do.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north (° ′)	Position: Longitude, west (° ′)	Nature of ice or obstruction
June 1	374	America	1 53	50 01	2 small bergs.
1	375	Veendam	42 09	48 50	Berg and 2 growlers.
1	376	Port Sydney	47 03	50 33	Berg.
1	377	do	47 00	50 24	Do.
1	378	do	47 07	50 09	Do.
1	379	do	47 01	49 52	Do.
1	380	do	47 19	49 46	Do.
1	381	Berk	47 19	51 28	Do.
1	382	Hilversum	47 34	50 19	Do.
1	383	do	47 00	50 41	Do.
1	384	do	47 16	49 54	Do.
1	385	Ice patrol	41 27	48 25	Berg, same as 371.
1	386	Innerton	42 08	49 15	Small berg.
1	387	Veendam	42 10	49 24	Berg.
1	388	Transylvania	47 18	51 30	Do.
1	389	do	47 27	50 59	Do.
1	390	do	47 07	50 36	Do.
1	391	do	47 34	50 54	Do.
1	392	do	47 33	50 40	Do.
1	393	do	47 16	50 16	Do.
1	394	do	47 37	50 52	Do.
1	395	do	47 41	50 24	Do.
1	396	do	47 54	50 06	Do.
1	397	do	47 50	49 59	Do.
1	398	do	47 50	49 48	Do.
2	399	Ice patrol	41 18	48 08	Berg, same as 371.
2	400	Bellflower	41 31	48 38	Large berg.
2	401	Drottingholm	42 00	49 02	Do.
2	402	do	42 02	49 06	Do.
2	403	Tiger	47 16 to 47 41	51 22 to 51 36	6 bergs.
2	404	Bolingbroke	47 10	50 10	Berg.
2	405	do	47 04	50 19	Do.
2	406	do	47 07	50 50	Do.
3	407	Ice patrol	41 00	48 38	Berg, same as 371.
3	408	do	41 15	48 38	Berg, same as 402.
3	409	Springbank	42 29	51 14	Berg, same as 337.
3	410	do	42 34	51 11	Berg, same as 338.
3	411	do	42 30	51 12	Small berg, same as 339.
3	412	Bronte	41 51	48 34	Berg, same as 403.
3	413	Lehigh	42 00	48 50	Small berg.
4	414	Ice patrol	41 06	48 27	Berg, same as 402.
4	415	Cape Race (station)	47 30	49 26	Berg.
4	416	do	47 18	49 59	Do.
4	417	do	47 14	50 15	Do.
4	418	do	47 12	47 47	Do.
4	419	Westphalia	42 38	51 09	Do.
4	420	do	42 47	51 01	Do.
4	421	do	42 44	51 12	Do.
4	422	American Shipper	41 57	49 28	Do.
5	423	Ice patrol	40 57	48 38	Berg and growlers, same as 402.
5	424	Unknown ship	46 50	51 10	Very large berg.
5	425	Cape Race (station)	47 32	50 12	Berg.
5	426	do	47 50	50 18	Do.
5	427	do	47 12	50 17	Do.
5	428	do	47 18	49 53	Do.
5	429	do	47 24	49 50	Do.
5	430	do	47 26	49 37	Do.
5	431	do	47 15	49 35	Do.
5	432	do	47 25	49 25	Do.
5	433	John W. Mackay	42 58	51 25	Do.
5	434	do	42 49	51 23	Do.
6	435	Ice patrol	40 57	48 38	Berg, same as 402.
6	436	Roussillion	42 55	49 11	Berg.
6	437	do	42 59	49 56	Do.
6	438	Berk	43 06	52 13	Do.
6	439	do	42 55	51 19	Do.
6	440	do	42 58	51 25	Do.
6	441	do	42 46	47 47	Do.
7	442	Aurania	47 35	49 35	Berg and growler.
7	443	Cape Race (station)	47 04	50 49	Berg.
7	444	do	47 58	49 07	Do.
7	445	do	47 35	49 55	Do.
7	446	do	47 31	49 45	Do.
7	447	do	47 58	48 17	Do.
7	448	do	47 59	48 14	Do.

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Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
June 7	449	Cape Race (station)	47 48	50 27	Berg.
7	450	do	48 42	49 02	Do.
7	451	do	48 34	49 16	Do.
7	452	do	48 30	49 20	Do.
7	453	do	48 28	49 20	Do.
7	454	do	47 42	51 09	Do.
7	455	Aurania	47 45	49 49	Do.
7	456	do	47 32	49 37	Do.
7	457	do	47 35	49 35	Do.
7	458	do	48 03	49 07	Do.
7	459	do	48 18	48 51	Do.
7	460	do	48 05	48 18	Berg 160 feet high.
7	461	do	48 12	48 21	Berg.
8	462	Calumet	47 35	49 31	Berg and growlers.
8	463	Cape Race (station)	47 50 to 48 42	48 18 to 51 15	Many bergs and pieces of ice.
9	464	Montroyal	47 28	49 51	Low-lying berg.
9	465	Cleveland	40 17	56 07	Red spherical buoy.
9	466	Deuteldijk	34 34	50 46	Red and black bell buoy.
11	467	Antonia	47 41	48 48	Large berg, several growlers
11	468	do	47 34	48 48	Low-lying berg.
11	469	Cape Race (station)	47 02	57 55	Wreckage of schooner.
11	470	do	47 27	50 54	Berg.
11	471	do	47 45	50 29	Do.
11	472	do	South Cape Francis		5 bergs.
11	473	do	47 37	49 28	Berg.
11	474	do	47 46	48 37	Do.
11	475	do	47 33	49 24	Do.
11	476	do	47 33	49 28	Do.
11	477	do	47 32	49 33	Do.
12	478	Livenza	42 49	49 18	Do.
12	479	do	42 50	49 08	Do.
12	480	Cape Race (station)	47 41	47 31	Large berg.
12	481	do	47 35	48 52	Berg.
12	482	do	47 57	50 03	Do.
12	483	do	47 25	51 40	Do.
13	484	Drammensfjord	46 06	48 38	Do.
13	485	Nesstad	43 08	50 10	Do.
14	486	Cape Race (station)	47 14	48 37	Berg and growlers.
14	487	do	46 45	52 50	Berg.
14	488	do	45 19	48 00	Large berg.
14	489	Estonia	47 45	51 07	Do.
14	490	do	47 53	51 15	Do.
14	491	Delaware	47 28	51 23	Small berg.
15	492	Cape Race (station)	47 30	52 30	Berg.
15	493	do	47 22	50 34	Do.
15	494	Alaunia	47 09	50 00	Do.
15	495	Unknown ship	47 21	50 16	Do.
15	496	do	47 47	49 13	Do.
15	497	do	48 00	48 44	Do.
15	498	Caledonia	48 07	48 35	Do.
15	499	Doric	48 14	49 06	Do.
15	500	do	48 13	49 16	Do.
15	501	do	49 12	49 21	Do.
15	502	Alaunia	47 50	47 13	Do.
15	503	Nova Scotia	47 51	52 15	Do.
15	504	do	47 51	52 04	Do.
15	505	do	48 10	51 54	Do.
15	506	do	48 17	51 17	Do.
15	507	do	48 25	50 57	Do.
15	508	Canadian Transporter	47 32	50 17	Do.
15	509	Cape Race (station)	46 45	52 53	Do.
15	510	do	47 23	51 21	Do.
15	511	do	47 47	50 16	Do.
15	512	do	48 14	49 09	Do.
15	513	do	48 20	48 50	Do.
15	514	do	47 09	50 00	Berg, same as 497
15	515	do	47 23	50 04	Berg.
15	516	do	48 37	51 31	Do.
15	517	do	47 35	51 40	Do.
15	518	do	47 30	48 25	Do.
15	519	do	47 21	50 00	Do.
15	520	do	46 55	52 35	Do.
15	521	do	47 00	52 22	Do.
15	522	do	47 14	51 42	Do.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north		Position: Longitude, west		Nature of ice or obstruction
			°	′	°	′	
June 15	523	Cape Race (station)	47	44	50	55	Berg.
15	524	do	47	30	50	37	Do.
15	526	do	47	50	47	13	Do.
16	527	do	47	51	52	15	Do.
16	528	do	48	17	51	01	Do.
16	529	do	48	25	50	57	Do.
16	530	do	47	35	51	11	Do.
16	531	do	47	27	51	07	Do.
16	532	do	47	13	51	30	Do.
16	533	do	47	56	49	50	Do.
17	534	Ascania	48	30	45	55	Do.
17	535	Montrose	48	07	49	38	Growlers.
17	536	do	47	52	50	04	Berg.
17	537	do	47	55	49	26	Do.
17	538	Sydland	44	40	45	35	Do.
17	539	King Gruffydd	45	32	48	04	Small berg.
17	540	Transylvania	47	17	50	40	Large berg.
17	541	Greldon	43	45	51	11	Small berg.
17	542	Transylvania	46	36	52	56	Berg.
17	543	do	46	24	53	10	Do.
17	544	Letitia	47	17	50	14	Do.
17	545	do	48	11	49	22	Do.
17	546	Montrose	47	06	51	27	Small berg.
18	547	Valemore	47	29	48	04	Berg and growler.
18	548	do	46	50	50	15	Berg.
18	549	do	46	48	50	40	Do.
19	550	United States	42	25	49	07	Small berg and growler.
20	551	Cape Race (station)	46	52	48	05	Berg.
20	552	Denham	44	50	45	55	Small berg.
20	553	do	44	48	46	30	Large berg.
20	554	Metagama	46	15	53	06	Small berg.
21	555	Montroyal	47	30	49	59	Large berg.
21	556	do	46	28	51	45	Berg.
21	557	do	46	14	53	05	Growler.
21	558	Norefjord	46	35	54	00	Berg.
21	559	Unknown ship	44	76	45	40	Do.
21	560	Trelissick	46	20	53	10	Growler.
21	561	Cape Race (station)	47	50	48	33	Berg.
21	562	do	47	35	49	50	Do.
21	563	do	46	56	51	36	Do.
21	564	do	47	03	50	54	Do
21	565	Bleddyne	46	02	47	02	Do.
21	566	Cape Race (station)	47	53	51	00	Do.
21	567	do	47	40	50	54	Do.
21	568	do	47	05	50	37	Do.
22	569	do	47	12	51	24	Do.
22	570	do	46	59	51	32	Do.
22	571	do	47	20	51	30	Do.
22	572	do	47	20	50	50	Do.
22	573	do	46	02	47	20	Do.
22	574	do	47	26	51	40	Do.
22	575	do	46	58	51	21	Do.
22	576	do	47	07	50	47	Do.
22	577	do	47	28	49	51	Do.
22	578	do	47	20	49	44	Do.
23	579	Montcalm	47	48	50	40	Do.
23	580	do	47	52	50	48	Do.
23	581	Antonia	46	24	52	28	Do.
23	582	do	46	57	51	55	Do.
23	583	do	46	58	51	22	Do.
23	584	do	47	37	49	56	Do.
23	585	do	46	30	52	45	Do.
23	586	do	47	07	50	55	Do.
23	587	do	47	34	48	43	Do.
23	588	Ulmus	42	26	45	28	Growler.
23	589	Cape Race (station)	47	48	50	40	Berg.
23	590	do	47	52	50	48	Do.
23	591	do	48	43	50	30	Do.
23	592	do	48	56	50	00	2 large bergs.
24	593	do	47	12	50	50	Berg.
24	594	do	48	39	49	58	Do.
24	595	do	47	39	50	57	Do.
24	596	do	46	48	52	36	Do.
24	597	do	48	50	50	10	Do.
24	598	do	49	07	49	30	Do.
24	599	do	46	45	52	45	Do.

Table of ice and of other obstructions, 1926—Continued

Date	No.	Vessel reporting	Position: Latitude, north		Position: Longitude, west		Nature of ice or obstruction
			°	′	°	′	
June 24	600	Cape Race (station)	47	24	51	30	Berg.
24	601	Zeeland	47	31	49	40	Do.
24	602	do	47	11	50	46	Do.
25	603	Cape Race (station)	47	30	51	24	2 bergs.
25	604	do	48	31	51	59	Berg.
25	605	do	48	40	50	46	Do.
25	606	do	48	27	51	28	Do.
25	607	do	48	24	51	32	Do.
25	608	do	48	31	51	08	Do.
25	609	do	46	49	52	37	Do.
25	610	do	47	15	47	25	Do.
25	611	do	47	02	47	40	Do.
26	612	do	47	39	49	35	Do.
27	613	Beemsterdijk	47	10	49	38	Small berg.
27	614	Cape Race (station)	47	39	49	35	Berg.
27	615	do	48	09	44	44	Do.
27	616	do	47	30	50	39	Do.
27	617	do	47	53	49	47	Do.
27	618	do	46	49	52	01	Do.
27	619	do	47	10	49	38	Do.
27	620	do	48	05	49	05	Do.
28	621	Montrose	48	06	48	53	Do.
28	622	Cape Race (station)	47	40	51	19	Do.
28	623	do	46	52	52	02	Do.
28	724	do	47	50	49	55	Do.
28	625	do	47	39	49	52	Do.
28	626	do	48	18	50	01	Do.
28	627	do	48	16	48	49	Small patch of field ice.
28	628	do	47	50	49	55	Berg.
28	629	do	47	48	49	55	Do.
28	630	do	47	26	50	37	Do.
28	631	do	45	56	48	05	Do.
28	632	do	46	07	48	08	Do.
29	633	do	47	45	50	12	Growlers.
30	634	do	47	57	49	26	Berg.
30	635	do	48	19	52	17	Numerous small bergs
30	636	do	48	52	51	48	Berg.
30	637	do	49	04	50	49	2 large bergs.
30	638	do	47	50	49	20	Berg.
30	639	Ice patrol	41	50	51	45	Fisherman's buoy with cage; destroyed.

WEATHER—A BRIEF REVIEW OF THE 1926 ICE SEASON

EDWARD H. SMITH

As we sit down to write a worth-while, instructive report on the subject of weather, as it concerned the ice patrol of 1926, and in a sense as it probably concerns future patrols, we believe it most important to survey first only the principal features which were responsible in characterizing the 1926 season as a whole. Under this category comes foremost the steepness of the barometric gradients and the consequent great intensity of the winds that blew so constantly from the day we left Boston, March 25, until well along in April. It is impossible, of course, to place one's finger upon any definite date when a meteorological phenomenon such as we call "wintertime" conditions change to "summertime" conditions. This spring on the Grand Banks, however, we are convinced, that wintertime conditions prevailed longer than usual, and it was not until the latter part of April that we began to notice a slackening in the wind force, a dropping off in the frequency of storms, and a lessening in the tendency of great anticyclones to build up and spread eastward from the North American Continent. It also can be stated with considerable assurance that the atmospheric envelope was in a violent state of agitation from March 29 to April 20. During this period of 22 days the wind blew with gale force on 12 days, and there were only 2 days on which it did not attain a fresh to a strong breeze on the Beaufort scale. Before passing on from the remarks on wintertime meteorological conditions we should like to familiarize everyone with the general scheme of the air streams under which the ice regions come.

THE TWO MAJOR WEATHER TYPES WHICH PREVAIL IN THE ICE REGIONS

The ice season extending as it does from March to July bridges two main types of weather which standing at either end of the gamut we have termed wintertime and summertime conditions. This all important seasonal effect is of course superimposed upon the fundamental planetary system of circulation and is directly due to the thermal seesaw which is continually in process between land and water masses. In the North Atlantic (and controlling the weather of the ice regions), we have three great centers of action, triangularly located and with the relative condition of each determining the consequent behavior of the air: (*a*) the Icelandic minimum; (*b*) the

Azorean high; and (*c*) the continental effect of bordering land areas. Glancing at the normal isobaric map of the North Atlantic for the colder months of the year, the station normals of which are based upon average barometric records compiled over a long series of years, our eye is immediately caught by a huge elliptical-shaped depression near Iceland. And then we notice that in effect this depression is emphasized by the opposing anticyclonic conditions which prevail over the bordering land masses of the Atlantic basin. The geographical position of the Grand Banks in the western North Atlantic on the southwestern side of this mammoth cyclonic wind system, it is plain to see, subjects the iceberg regions south of Newfoundland to an air stream flowing from west to east, the swiftness of which is gale force the major part of the early season. Such prevailing circulation is, however, often subjected to short interruptions when cyclonic storm centers usually of marked intensity come from the United States and cross the ice regions. Now, during the latter half of the ice season the unequal rate of solar warming between land and water causes the wintertime high pressure to transfer from the land and increase over the ocean, thereby placing the Grand Banks region on the northwest side of a huge clockwise wind system. Gradients also become much reduced in steepness from what are found in winter season, and the warm southerly winds blowing over the icy waters around the Grand Banks bring a fog sheet which often does not lift for weeks at a time. This comprises a general survey of the two main types of weather and incidently it emphasizes two of the greatest handicaps the patrol is forced to encounter, namely early season gales and later season fogs.

If we return to a survey of the 1926 ice season we find no features of especial significance beyond the continuance of cyclone and anticyclone in alternate sequence following each other across the meteorological map from west to east, and in general with the progress of the season, gradients becoming gentler, winds weaker, and vortices traveling slower.

An interruption in the regularity of undulations to which the troposphere was subjected by alternate "highs" and "lows," occurred May 27 to June 2, when a great anticyclone built up and spread over the entire Atlantic seaboard from Florida to Newfoundland. It is rare to have such an atmospheric distribution but it means clear visibility and northerly winds for the ice regions; really the best weather we get on patrol.

DEVELOPMENT OF SUMMER TIME CONDITIONS

Going into June we began to notice the gradual development of the summer time Azorean high pressure as the thermal seesaw swung the opposite way from that observed at the beginning of the ice season.

At this time southwesterly winds began to blow with greater frequency and longer duration along the Atlantic seaboard of North America, and the ice regions being in the periphery of this system came under the effects of the southwest air stream more and more. The first real evidences of a hot wave over the United States was perceived the latter part of June.

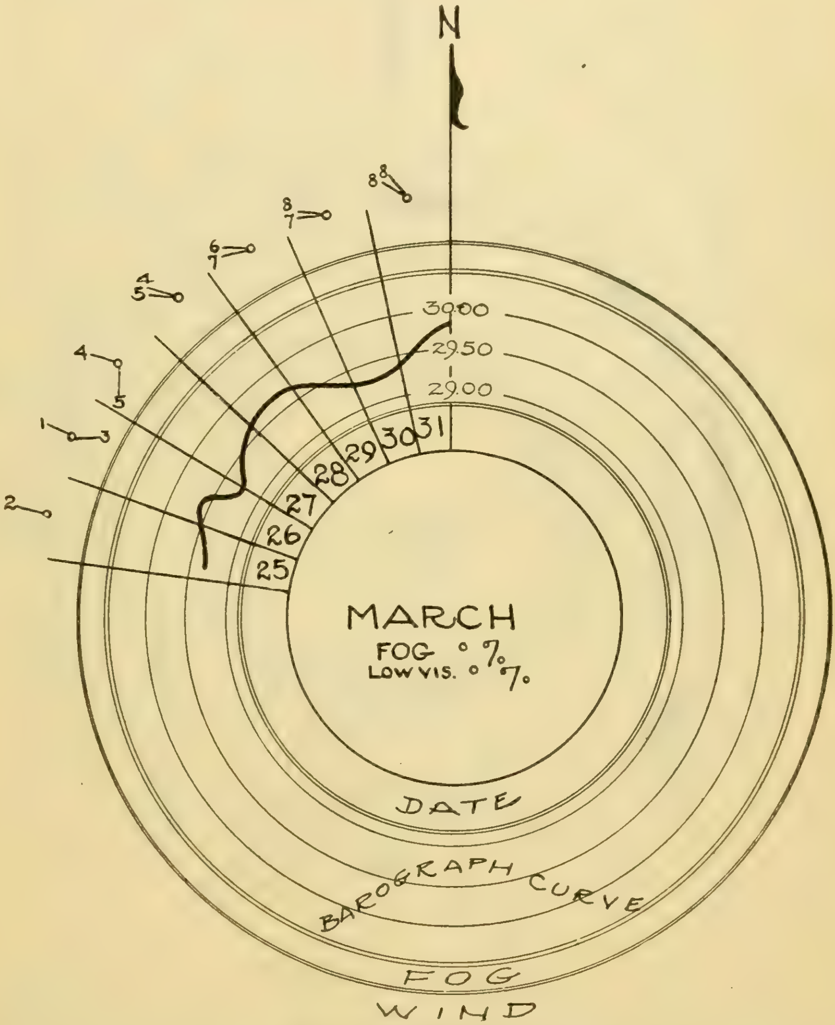

FIG. 1.—March weather diagram

WEATHER DIAGRAMS

In order to secure an intelligent impression of the general weather conditions which prevailed in the ice regions during 1926 we have constructed circular diagrams which include by months the following

information: Each diagram represents a month's time and is divided into 30 or 31 equal sectors in accordance with the number of days. The outer margin gives the wind direction averaged for each 12-hour period and also the force in terms of Beaufort scale. The next adjacent ring contains information on the amount of fog and

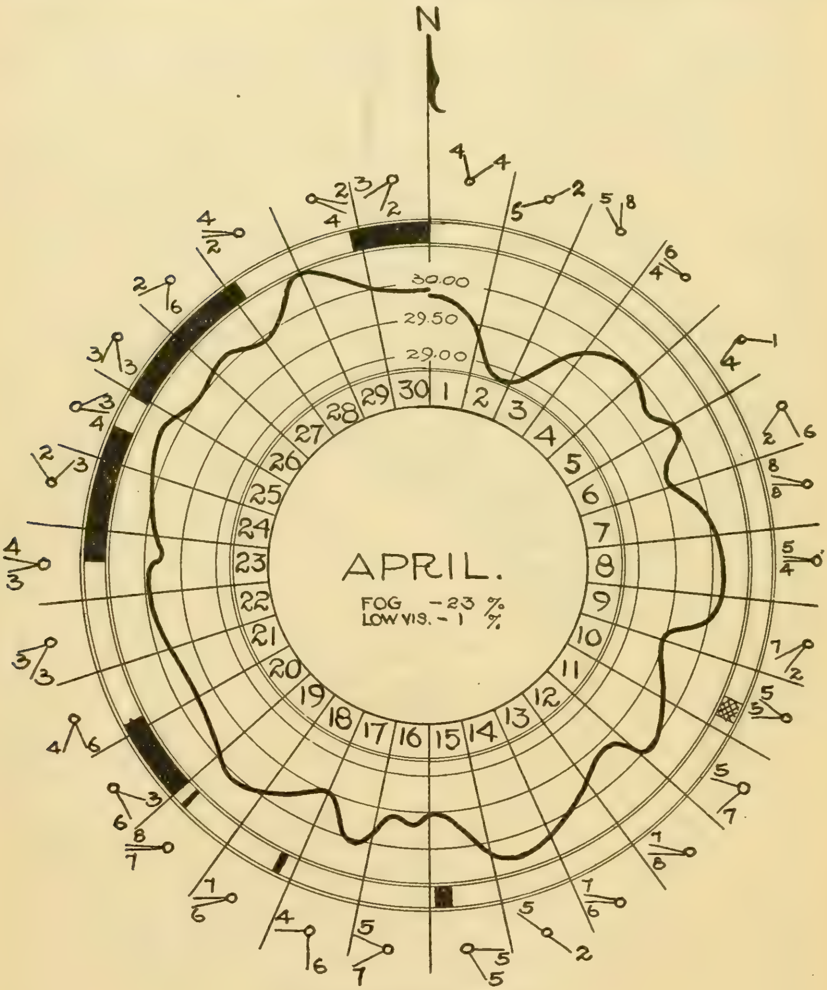

FIG. 2.—April weather diagram

low visibility experienced during the month; the fog is filled in full black and the low visibility in crosshatched shading. The third band in contains a continuous barograph record for the entire month and is drawn to scale. The numerals on the innermost ring signify the days of the month.

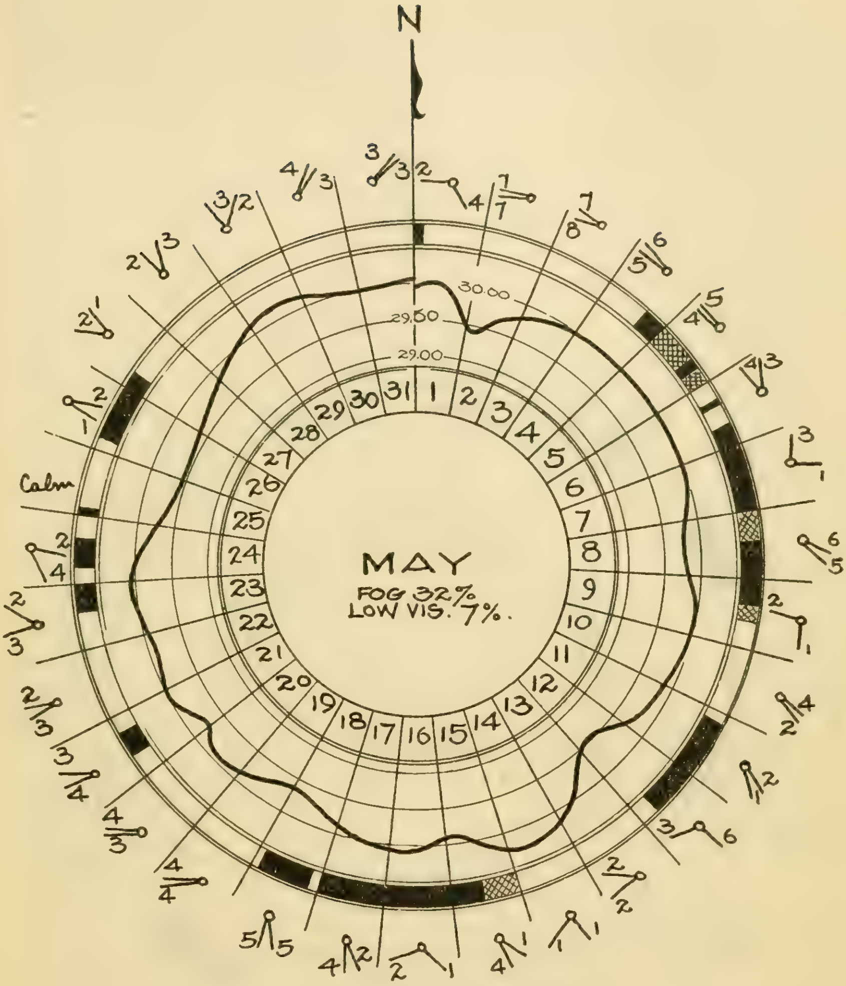

FIG. 3.—May weather diagram

Month	Percentage (hours)		Gales (number of days)[1]	Winds (average force)	Calms (number)[2]
	Fog	Low visibility			
March:					
Actual	0	0	3	5.0	0
Pilot chart	31				
April:					
Actual	23	1	9	3.8	0
Pilot chart	42				
May:					
Actual	32	7	2	3.1	1
Pilot chart	33				
June:					
Actual	12	2	0	2.8	2
Pilot chart	55				

[1] Based on 6 days in March. Gales per 12-hour periods. [2] Based on 12-hour periods.

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Fog was noticeably less than normal during April, normal during May, and very deficient in June. The absence of fog in this latter month is partly attributed to the fact that the position of the patrol vessel was unusually far south in the Gulf Stream during the first

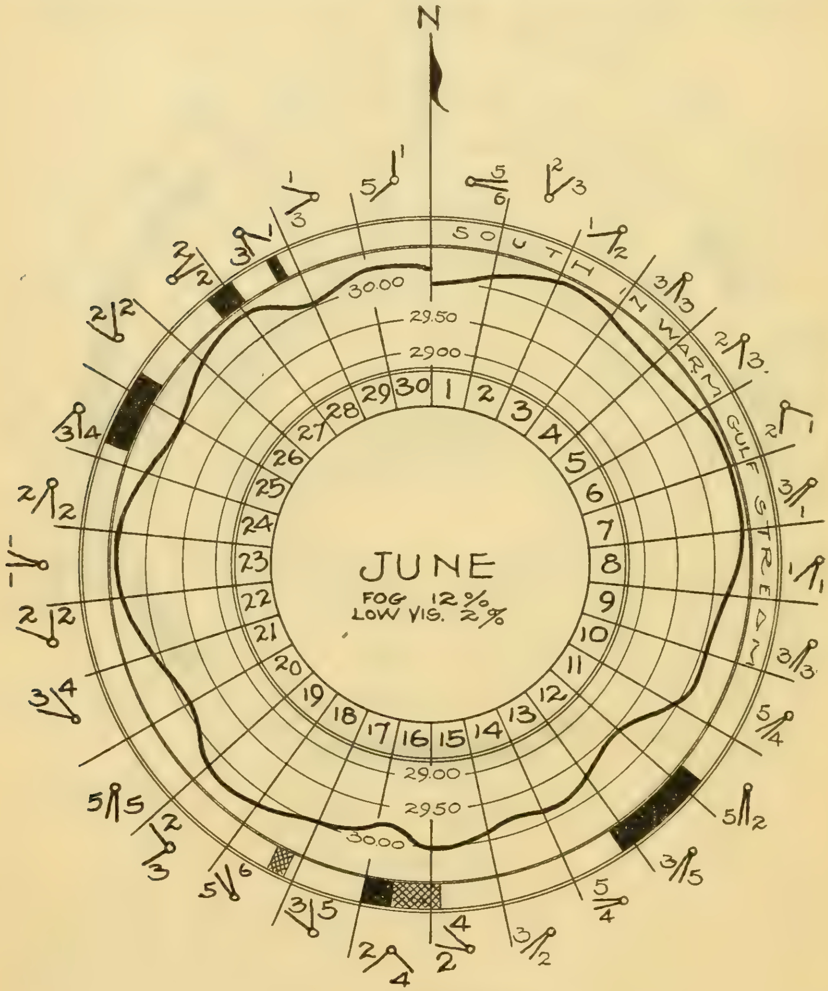

FIG. 4.—June weather diagram

half of the month and thus experienced clear weather. If she had been in the cold waters around the Tail of the Bank it is believed that almost constant fog would have been the order of the days.

CYCLONE TRACKS

Since the development and the passage of cyclones from the interior of the United States out across the ice regions is one of the most absorbing meteorological events with which we deal on patrol, per-

haps it will be of interest and instruction to describe the paths of some of the cyclones, rate of motion, and sequence in the procession which was observed.

MARCH

The weather conditions on March 25, our sailing day from Boston, consisted of a trough of low pressure stretched along the Ohio and St. Lawrence River Valleys and embracing a well marked center which was progressing northeastward. It was rather interesting to watch the path of this disturbance which has been plotted on Figure 5, page 38, as track A. The center, during the night of March 26, curved to the right and followed a southeasterly path to the vicinity of Sable Island. At 8 a. m. on the 27th it was located again on the weather map off Sydney, Cape Breton, and thence it moved in the more frequently traveled route toward the northeast. The excursion to the southward of the usual cyclone path was attributed in this case to the presence of a deficiency of pressure over the Carolinas combined with the blocking influence of a high pressure area to the northward. The subsequent behavior of this disturbance is worth a word or two. It can be seen by Figure 5, page 38, that the center moved northeastward for two days when somewhere east of Newfoundland it deepened and thus intensifying the gradient gave to the Grand Banks region strong westerly winds for several days. On March 31 an excess of air accumulated to the westward over the United States in sufficient proportions finally to remove all effects of our storm offshore into the ocean. (For a daily record of winds, pressures, and fog, reference may be made to the weather diagram, fig. 1, p. 33.)

APRIL

During the early part of the ice season the atmospheric envelope we repeat for emphasis, is usually in violent agitation; rocked intermittently, so to speak, as successive cyclonic vortices disturb the prevailing atmospheric pressure distribution. The normal pressure character for this time of year is one to which we have previously referred as wintertime, and is clearly identified by a dominating excess of pressure lying over the cold continental area as compared with the air mass over the warmer ocean. No sooner had March 31 marked the disappearance to the eastward of the storm center described above than it also ushered in a similar vortex in the troposphere, first noticed on our map for the eastern United States just south of Chicago, Ill. The career of this cyclone across the country and out to sea, March 31 to April 3, has been traced as track B, Figure 5, page 38. The effect of its approach was first detected when at a distance of 500 miles from the ice patrol ship, the barometric pressure began to fall the afternoon of April 1. The northwesterly winds which had been blowing with great intensity and duration ceased about this

time and a breeze sprang up from the northeast. The barometer continued to fall until noon the 2d, when it recorded what proved to be the minimum for the entire patrol (28.90; see weather diagram for April), and the depression must have passed about over our position south of Newfoundland. The winds with the passing of the center almost immediately shifted to northwest and increased that night to gale force. While we were still within the effects of the storm described above, a region of new depression was observed over the lower Mississippi River Valley. The path followed by this disturbance from April 2 to 7 is shown as track D, Figure 5. This center traveled along a path located a little farther to the northward than that of its predecessor. It followed a straight line more or less

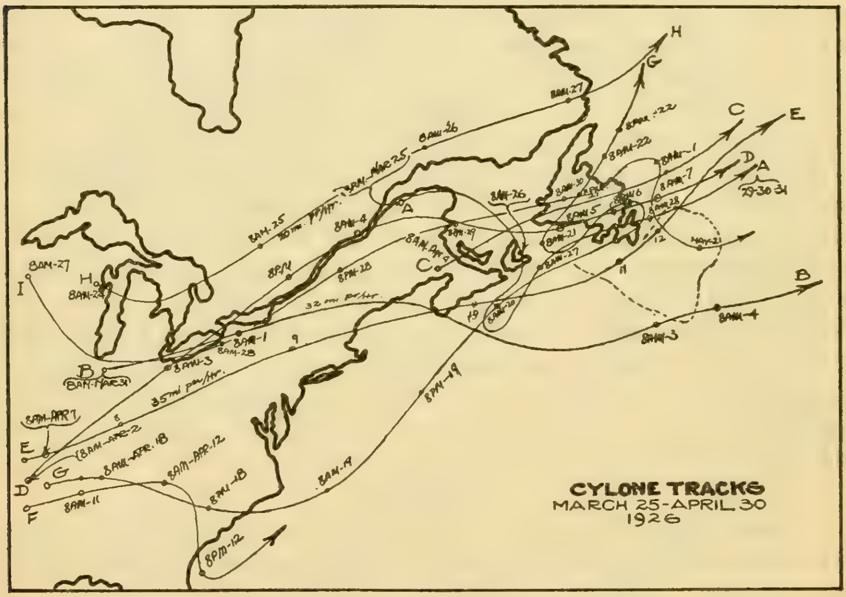

FIG. 5.—March and April cyclone tracks

up the St. Lawrence Valley until it arrived at the upper reaches of the gulf when it curved off to the right keeping over the water as much as possible, and slowly crossed southern Newfoundland on the 5th, 6th, and 7th. It is important to note that this cyclone, similar to several others which have been observed, deepened and intensified as it proceeded up the St. Lawrence River and Gulf. It deepened from a reported pressure in Mississippi of 29.76 to a minimum of 29.28 at Port aux Basque, Newfoundland, and it was at this point approximately 450 miles from the patrol ship that the first effects of the disturbance were felt. The wind shifted to southerly and the barometer fell but as the disturbance began to recede to the eastward it also began to occlude and the winds soon resumed their prevailing northwesterly direction.

While the foregoing storm was raging over Newfoundland another cyclone was growing down in Oklahoma. Its path from April 6 to 12 is lettered E on Figure 5. It followed the mean northeasterly track, as can be seen on the figure, and on the evening of the 11th when 300 miles from the position of the patrol ship it made its first effects felt by the wind increasing to nearly gale force from the south. As the storm moved away out into the North Atlantic we were completely enveloped in an anticyclone which was following on the rear of the "low," and for the next two days we experienced stiff northwesterly gales.

A moderate depression was observed on the meteorological map for 8 a. m., April 10 as centered in eastern Texas. It traveled very slowly in an easterly direction until the 12th when near Atlanta, Ga., it abruptly turned and followed a track almost due south for about 300 miles then reversed itself and moved northeastward. This peculiar behavior was believed due to the presence of an anticyclone of considerable size and intensity to the northward. The disturbance later spread southeastward over the Middle Atlantic States effectually blocking the normal cyclone path.

Track H of a cyclone, April 24 to 27, lay farther north than the other tracks for the month and being so far removed from the Grand Banks region its passing influence could not be detected on the barograph record. Track I, however, the last one for the month, lay up the St. Lawrence Valley so that the center, when it crossed the gulf the night of the 29th, was about 540 miles from the patrol. At this distance it caused our pressure to fall slowly and the winds to shift temporarily from west to east. The rate of travel of this cyclone was about 25 to 30 miles per hour. The month closed with this disturbance central over Newfoundland.

MAY

On May 1 the cyclone that had moved along track I began to drift southeasterly toward the patrol ship and consequently left a graphic record of a sharp bend in our barograph curve for the 2d instant. (See weather diagram for May, fig. 3, p. 35.)

The weather map which we compiled on board the morning of May 2 indicated another depression (29.70) forming to the westward over the Great Lakes region. First it followed an easterly path to the vicinity of Quebec where it hovered until May 3, then curved into northern Vermont and deepened to 29.30. April 4 it passed over the Gulf of St. Lawrence still intense (29.22), yet that evening it suddenly and surprisingly began to fill and by the following day it was very shallow and trough-like. May 6 it was almost squeezed out between two prominent areas of high pressure which merged and for several days prevented the regular procession of depressions which had been in effect prior to this.

It is interesting to observe that the easterly position of cyclone track B on Figure 6, was due without much doubt to the presence of the aforementioned anticyclone. Weather bulletins were received May 5, 6, and 7, containing information that a depression was forming in the region of Bermuda, but due to the lack of ship reports it was impossible to ascertain definitely the movement of the center. During the night of May 8 our barometer began to fall, which from past experience indicated the approach of a storm within a radius of about 500 miles. The next morning upon constructing the weather map the center was revealed near Port aux Basque; it probably had followed a northerly path from Bermuda as indicated on Figure 6. During the next few days the weather maps indicated a tendency of

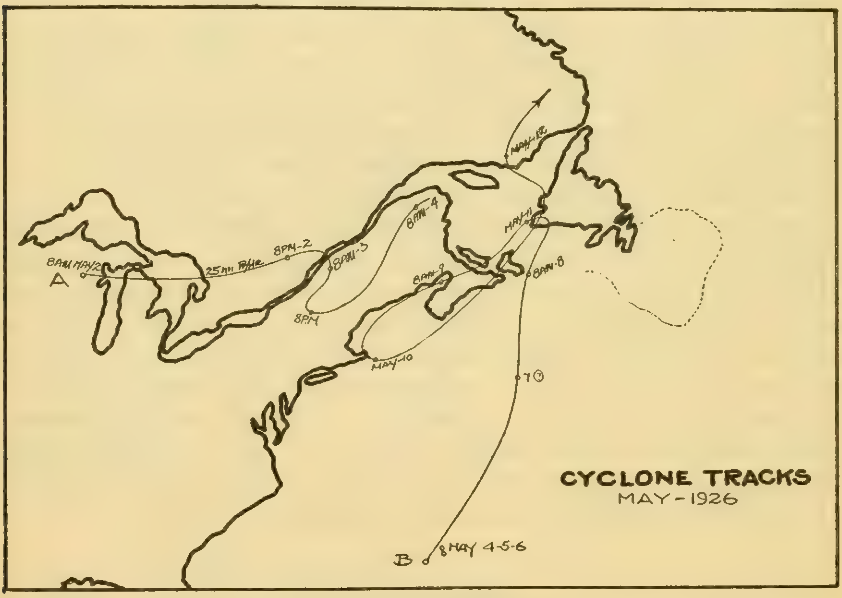

Fig. 6.—May cyclone tracks

the pressure to remain relatively low to the westward, depression centers being recorded from Nantucket to Sydney. On May 11 a deep center appeared near Sydney and moved in a path across the Gulf of St. Lawrence and out to sea. The effects of this distribution set up an indraft of southeasterly winds consisting of warm moisture-laden air pulled across the ice regions from out in the Atlantic. This condition incidently produced the longest period of fog which we experienced for the season.

The two weeks from the 13th to the 27th marked a change in the previously noted tendency of the cyclones to travel consistently along northeasterly tracks Where prior to this period individual centers moved rapidly across the country we now saw several small vortices (families) following meandering paths as if they were the

prey to several factors no one of which exerted outstanding control. For example, on May 13 a slight shallow depression moved from Illinois eastward to the Potomac and the next day spread into a spacious depression with two centers. One traveled eastward while the other remained stationary until two days later it coalesced with a third depression which had been drifting slowly eastward from the Great Lakes. Contemporary with this modification in the weather we noticed that the wind velocities in general had gradually become less than they had been earlier in the season.

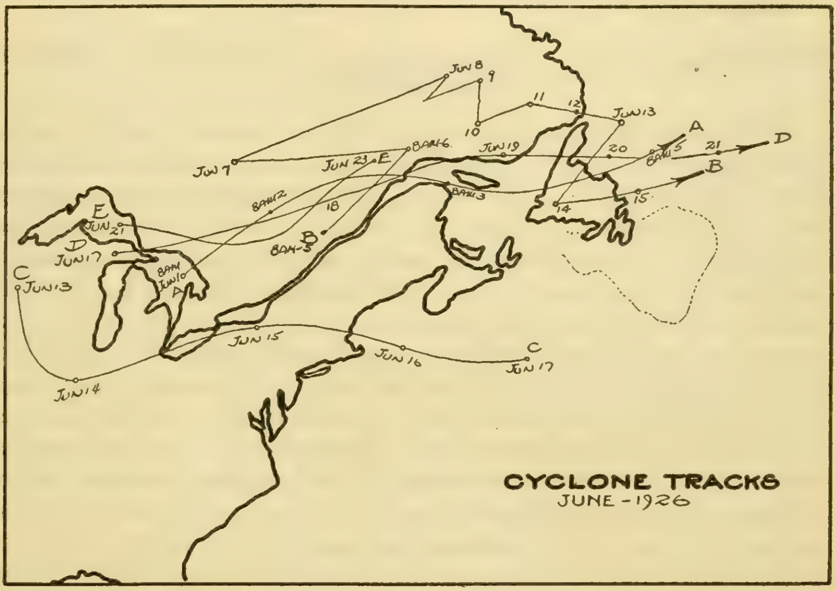

FIG. 7.—June cyclone tracks

May 25 to 30 an anticyclone of vast proportions expanded from the region of central Canada and spread over the entire eastern half of the United States and extended out to include the ice regions. It finally divided into two centers and soon afterward disintegrated completely. It is interesting to examine the flatness of the barograph curve and the presence of clear weather, both of which are recorded on Figure 3, page 35.

JUNE

The most important lesson contained in the cyclone tracks for June (fig. 7) is obtained by comparing the position of the average with the position of the average for the months of March and April. It is clearly indicated that a migration to the northward of the mean cyclone track took place in the course of two months. It is estimated as approximately 150 miles. The explanation for track C, Figure 7,

being much farther south than the others is to be found when reference is made to the daily weather maps. An anticyclone of considerable strength spread southward out of the region north of the St. Lawrence River and probably tended to push cyclone C farther south than it would otherwise have traveled.

The next most striking weather feature in June was the increased number of cyclone families which bred in central North America and persisted in occupying pretty much all of the region northward of a front that extended from the Great Lakes to east of Newfoundland.

PERSISTENCY OF A DEPRESSION IN THE REGION EAST OF NEWFOUNDLAND

Many times during the spring of 1926 we observed that the region immediately east of Newfoundland, and often the Newfoundland area itself, was for days the seat of a deficiency of atmospheric pressure. This persisted so markedly that the phenomenon is regarded not simply as a peculiarity of one season but rather as a general characteristic of all years. As an illustration of the manner in which individual depressions (or a permanent general depression?) may persist in a given region we point to the meteorological maps from 8 a. m. April 15 to 8 a. m. of the 19th during which time the pressure in the Newfoundland theater was constantly lower than that surrounding it to the west and south. The fact that there are observation stations on these three sides of Newfoundland permits one to construct an accurate isobaric map, but it does not throw any information whatsoever on conditions in process in the quarter northeast of Newfoundland. It is easy to see then that we are unable to fix the position of storm centers after they have reached this vicinity, and therefore when we continue to receive reports of low barometer readings from St. Johns it is a natural tendency to conclude the cyclone has paused in its northeasterly progress, but the truth of this opinion is open to question. It may be clearer to regard a series of monthly mean pressure maps of the entire North Atlantic, which over a series of years will reveal the presence of a mammoth depression central near Iceland. It is believed that the continual presence of a depression observed east of Newfoundland on the ice patrol weather maps is in reality the western influence of the great Icelandic minimum accentuated by convergence while crossing Newfoundland of individual North American cyclone centers.

THE STRUCTURE OF A STORM AND ITS PROBABLE PATH

It may be instructive to devote a few very brief remarks to the new ideas in meteorology on the structure of cyclones (storm depressions) and their probable lanes of travel. Forecasters in the past

have usually been guided by the mean cyclone track, as compiled by the statistician, and the barometric tendency gained by simultaneous observations from scattered meteorological stations. Probably some of the most valuable recent contributions to the forecasting art are the investigations of Bjerknes into the structure of cyclones. Detailed analysis of individual cyclones revealed the following two main types of classification:

(*a*) Cyclones which have a definite warm sector separated from the cold part by definite surfaces of discontinuity.

(*b*) Cyclones exhibiting no such individual parts at the surface of the earth.

The former are young intensifying storm centers while the latter are old ones which tend toward retardation in their paths. When they are treated separately a real discovery was made that class A cyclones move in the direction of the air current in the warm sector and very nearly with the same speed as the velocity of the air in that sector. Since the direction of the wind is taken along the isobars, the direction of travel of the storm center shown in Figure 8, page 44, is AB. The isobars in the warm sector are drawn nearly straight because it is found in general practice that they are quite flat. The speed of the cyclone is found by multiplying the distance between the isobars by the sine of the latitude. The whole wind system is in motion and as a rule the direction of the isobar AB in the northern hemisphere will swing anticlockwise and the path of the center O will gradually curve to the left. Sometimes, however, when a small cyclone moves along the edge of a warm anticyclone the change is in the opposite direction. Bjerknes at the Geophysical Institute, Bergen, has found that class B cyclones although not having distinct discontinuity surfaces such as class A exhibit on the earth's surface, do have weather characteristics which correspond to these latter and which do furnish similar information on the career of class B cyclones.

The cyclone is said to be born when two air masses of differing densities come within proximity of each other; the thermal character of the two bodies is the usually accepted index. There follows a period of growth with a corresponding increase in intensity so long as the structure is fed by a sufficient supply of cold and warm currents. Class A cyclones eventually begin to fill up or occlude as the lower limits of the warm sector lift off the earth's surface and shallow out. They are then known as class B cyclones, and the discontinuity surfaces are only to be found at increased heights in the troposphere.

A great number of the storms which affect the ice regions in early season are class A cyclones and it is quite often the case that we are able to observe the passage of the surface of discontinuity in many well-

developed disturbances. The first line of discontinuity to sweep across the observer's position is termed the warm front and this carries along with it the greatest abundance of precipitation. Coincident with the passage of the warm front the winds haul abruptly and also abate in force. The warm sector is characterized by warm moisture-laden air, overcast skies, reduced visibility, less intense winds and occasional rain showers. The second line of discontinuity is called the cold front and squall line. The direction of the wind at this place

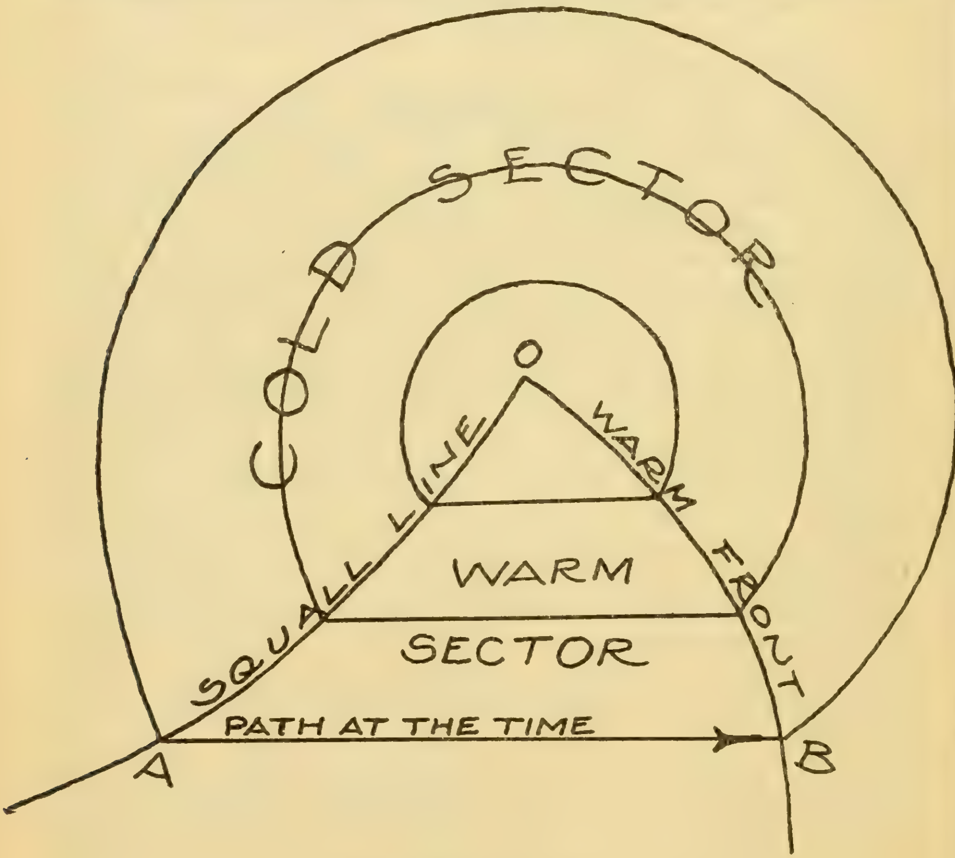

FIG. 8.—The structure of a cyclone

changes quickly to the right, the temperature drops precipitously, and the skies clear. The cold front is often accompanied by rain or hail squalls and perhaps also thunder and lightning and a strengthening of the wind. All of these are interesting to follow: The barograph curve, the wind velocity and direction, the air temperature, and the precipitation during the passage of some of the storms we experience on patrol. Often one can preceive how definitely, even in a crude way, the general structure of a cyclone can be traced.

COOPERATION WITH THE UNITED STATES WEATHER BUREAU

As was done on previous patrols a meteorological map was constructed twice daily on board ship, the data being obtained from the general synoptic reports broadcasted by the United States Weather Bureau from Arlington at 10 a. m. and 10 p. m. In addition to this the patrol ship was furnished with a daily forecast especially prepared by the Weather Bureau. All this information was broadcasted by phone to approaching steamers immediately following the ice broadcasts. The report on fog conditions was one of the most important features of this service from the standpoint of the steamship captain. The element of fog to the Grand Banks region, it is obvious, greatly increases the ever-present danger of collison with ice.

Twice daily, at 8 a. m. and 8 p. m., a weather report was dispatched to the United States Weather Bureau, Washington, D. C., and at the end of each cruise a more detailed report was forwarded by mail to Washington weather officials.

ICE FORECASTING BY MEANS OF THE WEATHER

One of the more important scientific problems that has confronted the ice patrol for some time is the desire to obtain advance information regarding the annual amount of ice to be expected south of Newfoundland. If the master of the *Titanic* had known, as we can clearly see to-day, that the year 1912 was one in which icebergs by the hundreds invaded the North Atlantic to low latitudes, he would probably have navigated his command farther south, and more cautiously, past the Arctic ice barrier. The amount of ice drifting out of the north into the open Atlantic is subject to great annual variations, for instance, in 1912 there were approximately 1,200 bergs counted south of Newfoundland while in 1924 there were only a total of 11. Several investigations[1, 2, 3] have been made of the relation between the amounts of ice in the northeastern North Atlantic and logical contributary factors, but only a few similar papers have dealt with the ice stream past Newfoundland.[4, 5]

All of the investigators, Schott, Mecking, Brenneck, Weisse, and Meinardus found that the wind was the most important factor which governs the southward drift of Polar ice. The ice patrol with the assistance of the British Meteorological Office and more recently, the United States Weather Bureau, has begun an investigation into the

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[1] Meinardus, W.: Periodische Schwankungen der Eisdrift. Ann. Hydr., Hamburg, 1906; pp. 148–149 227–239, 278–285.

[2] Weise, W.: Polareis und atmospharische Schwankungen. Geo. Ann. Stockholm, 6 (1924); pp. 273–299.

[3] Brennecke, W.: Beziehungen zwischen der Luftdruckverteilung und den Eisverhaltnisse des Ostgroen landischen Meeres. Ann. Hydr., Hamburg, 1904; pp. 49–62.

[4] Mecking, L.: Die Eisdrift aus dem Bereich der Baffin Bai usw. Veroff. Inst. Meersk, Berlin 7, 1906; p. 148.

[5] Schott, G.: Uber die Grenzen des Treibeises bei der Neufundlandbank sowie uber eine Beziehung zwischen neufundlandischen und ostgronlandischen Treibeis. Ann. Hydr., Hamburg, 1904; pp. 305–309.

effect of the weather upon the distribution of icebergs. It is desired therefore under this section devoted to weather to give a brief account of the results so far of this research work. The period embraces 47 years, 1880–1926, a series of sufficient length to permit mathematical correlation, and in this respect it has an advantage over previous works.

The results differ somewhat from those previously obtained by Mecking in that the chief importance is assigned to the variations of the pressure difference between Belle Isle, in Newfoundland, and Ivigtut in southern Greenland, during the period December to March. The pressure difference directly affects the amount of field ice, and

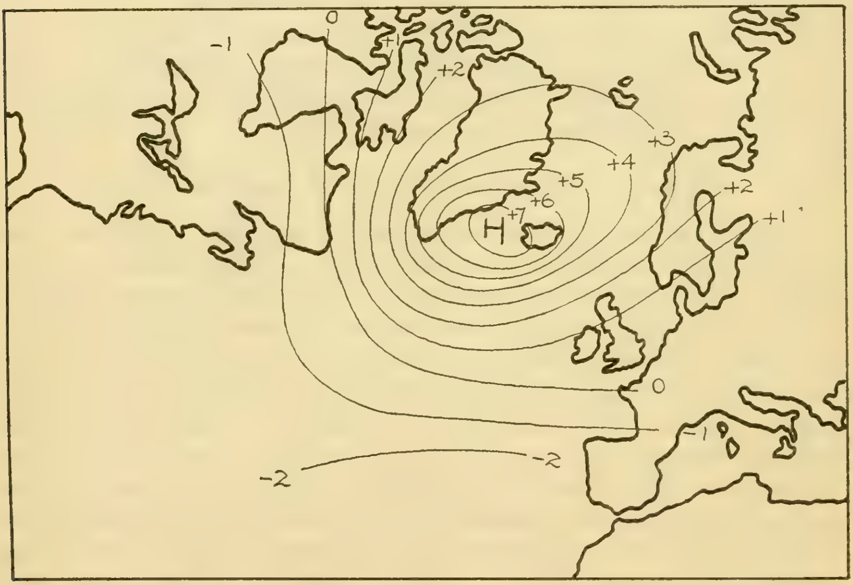

FIG. 8a.—The atmospheric pressure map constructed by averaging the pressures for the months of December to March in the years 1881, 1891, 1895, 1900, 1902, and 1917. These years were all characterized by a lesser amount of Arctic ice drifting into the western North Atlantic than usual. (See fig. 23.)

it has been found that there is a very close relation between the amount of field ice and the number of bergs south of Newfoundland. The field ice tends to act as a fender along the shoreward side of the Labrador current, and thus more or less prevents the bergs from stranding as they are borne southward. The truth of this statement was curiously revealed during the 1924 patrol, when the unusual absence of field ice left the season's crop of bergs to strand in northern waters. When the sea ice recedes northward, due to melting in May, the coast line becomes more and more exposed. Stranding takes place on a great scale, and the consequent supply of bergs to the Grand Banks is cut off. The iceberg menace to steamships in the North Atlantic would be greatly diminished, or prac-

tically disappear, if sea ice did not hamper the North American coast line from February to March every year. The pressure difference between Bergen and Stykkisolm during the period October to January was also found to be of importance.

The use of pressure difference between various points furnishes the best data for forecasting purposes, because there is no room for the personal bias which may come in when charts are classified according to types. A classification of the charts of pressure anomaly over the North Atlantic during the period December to March has, however, been made, and this distinctly reveals two types of pressure distribution—a plus type, in which an excess of pressure

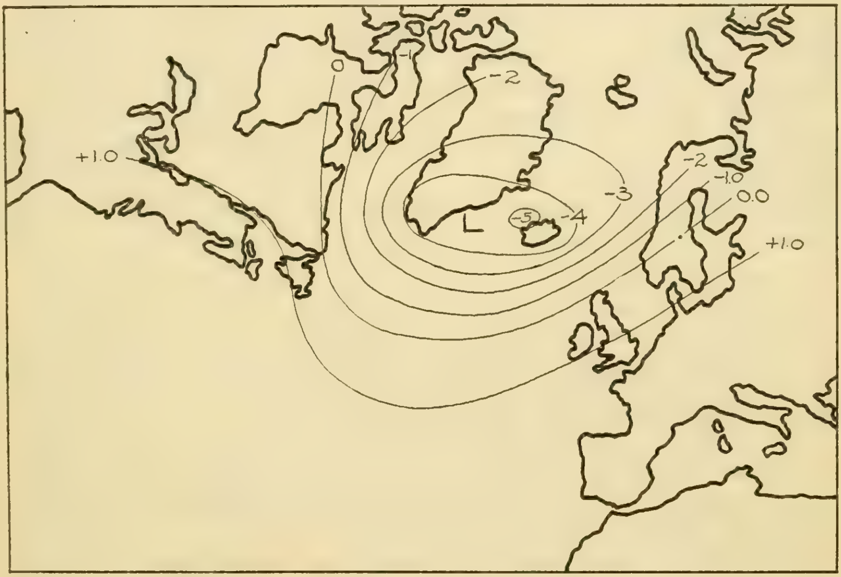

Fig. 8b.—The atmospheric pressure map constructed by averaging the pressures for the months December to March in the years 1885, 1890, 1903, 1912, and 1921. These years are characterized by a greater amount of Arctic ice drifting into the western North Atlantic than usual. (See fig. 23, p. 76.)

centered in the region of Iceland, more or less dominates the Atlantic north of the Azores (see fig. 8a, p. 46), and a minus type when reverse conditions prevail (see fig. 8b, p. 47). The plus type is subject to further classification into (1) and (2), depending upon a relatively great or moderate intensity of the excess pressure mass, both of which are reflected in a relatively very light, or light ice year, respectively, in the western North Atlantic. The minus type, although unmistakably showing a greater amount of ice than normal, does not permit subgrouping. In other words, the plus type of pressure conditions (fig. 8a) exhibit a higher correlation with poor ice years than do the minus type (fig. 8b) with correspondingly rich ice years. This indicates the presence of other factors, such as variations in

the air and water temperatures in the far north, or variations in precipitation, or perhaps an unnatural phenomenon, such as an ice jam in the Arctic Archipelago.

Although the investigation is not yet completed at the present writing, the results already indicate a high degree of success for such a method of ice forecasting. Correlation coefficients have been calculated between the following variables:

(*a*) Number of bergs (on a scale of 0 to 10). (See fig. 23, p. 76.)

(*b*) Amount of field ice (on a scale of 0 to 10).

(*c*) Pressure difference (in millibars) between Belle Isle and Ivigtut, combined with a deviation of pressure from normal at Stykkisholm during the period December to March. The mean pressure difference is calculated from the combination: $2 \times$ Dec. $+$ $2 \times$ Jan. $+ 1 \times$ Feb. $+ 1 \times$ March and this mean is combined with the pressure deviation at Stykkisholm in the proportion of 6 to 1.

(*d*) The pressure difference between Stykkisholm and Bergen during the period October to January, inclusive, December being given double weight.

The correlation coefficients employed in the preparation of the forecast were as follows:

Between (*a*) and (*b*)	+0. 85
Between (*a*) and (*c*)	−0. 58
Between (*a*) and (*d*)	−0. 63

At the end of March a forecast of the number of bergs can be prepared by means of the regression equation:

$$\text{Bergs} = 4.8 - 0.08\ (c) - 0.12\ (d)$$

At the end of the field ice season, April 15, the number of bergs, May to July, can be predicted very closely by making use of the high correlation between field ice and bergs.

Arrangements have been made with the United States Weather Bureau whereby that organization furnishes the ice patrol with the pressure data for the months October to March, inclusive, and upon which is based the forecast of bergs for the following spring season. The forecast for the ice season of 1926 was "a light ice year," (3.4 on scale 0–10), while as a matter of record it developed that we experienced very closely to "a normal season 4.3." It is fair to add that we were handicapped in making a forecast due to the absence of pressure data from a very critical area, that of Greenland. This difficulty will probably not arise again as Greenland meteorological stations are now connected with Europe by means of radio.

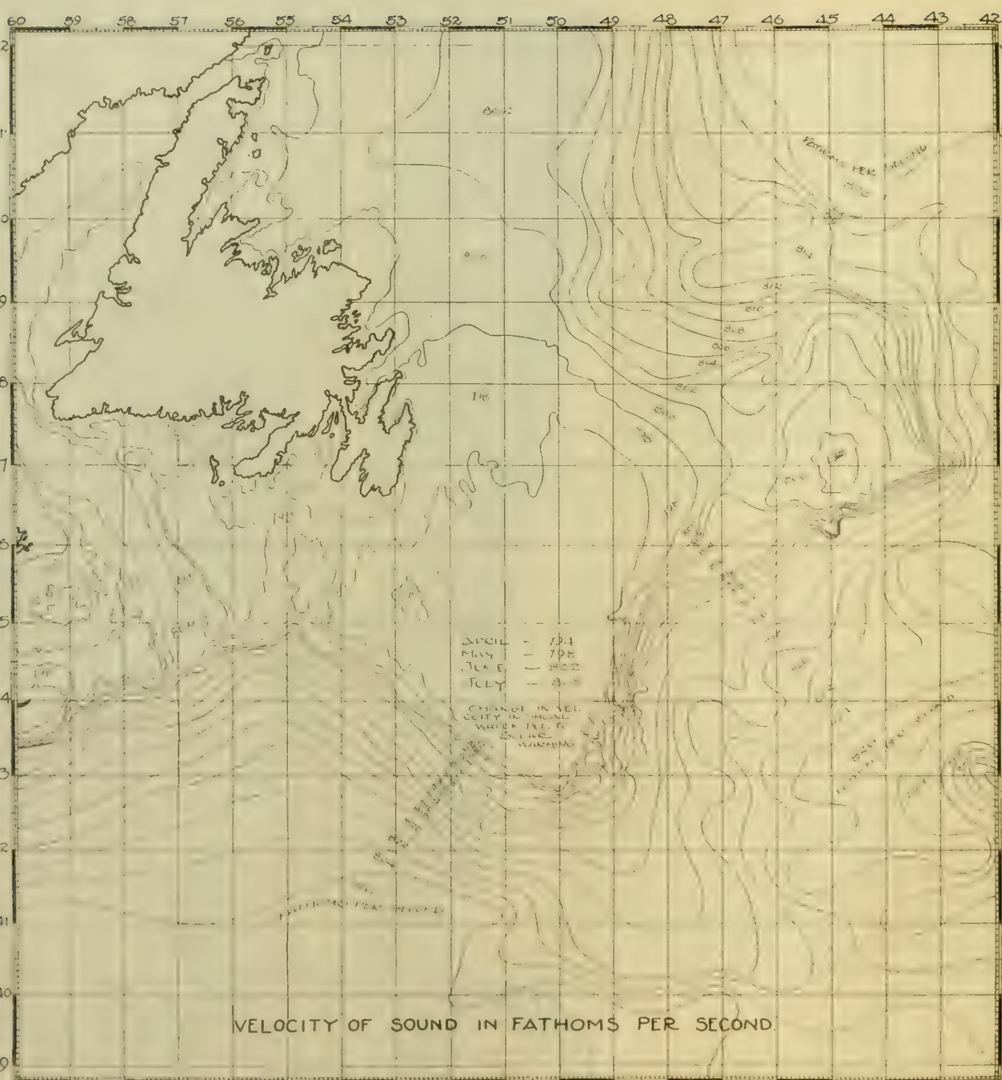

FIG. 9.—A chart for use with the sonic depth apparatus showing the velocity of sound in the water column around the Grand Bank

SOUNDINGS CARRIED OUT WITH THE SONIC DEPTH FINDER

As a result of action on the part of the Interdepartmental Board on Ice Patrol at its regular meeting in the early part of 1924 one of the ice patrol ships, the *Tampa*, was equipped with a sonic depth finder of the United States Navy type. The main purpose of the board in having this apparatus installed was to test the practicability of locating icebergs by sonic means. A secondary object was to gain a more accurate knowledge of the bottom contour and consequently of the circulation in the ice regions. An account of the experimental work on icebergs in 1925 and the hydrographical soundings then taken are contained in the report of that year, Bulletin No. 13, page 45. No further work in connection with sound experiments on bergs was attempted in 1926. Arrangements, however, were made whereby a member of the United States Navy sound course at the New London school was detailed to the *Tampa* for the ice patrol. A program was drawn up to take as many soundings as practical to gain further material for a more accurate mapping of the bottom of the ice regions south of Newfoundland than is yet possible, and this work ought to be continued in the years to come. In accordance with the foregoing, a sounding was taken every hour, 8 a. m. to 10 p. m., while the *Tampa* was on duty this year with the result that a total of 465 observations were made.

In connection with this work a chart was constructed (fig. 9, p. 49) to include the ice regions south of Newfoundland showing by zones the velocity of sound after corrections had been made for the influences arising from pressure, temperature, and salinity. The distribution of salinity and temperature in the water mass in the ice regions is quite accurately known from the many oceanographic observations which have been compiled by the ice patrol. The correct velocity of sound in a water column of given temperature, salinity, and pressure is found by reference to very useful tables compiled by Heck and Service. (U. S. Coast and Geodetic Survey, Special Publication, No. 108.) The range of soundings made was from 23.5 fathoms to 2,850 fathoms. The list follows with date, hour, and latitude and longitude.

SOUNDINGS AS RECORDED WITH THE SONIC DEPTH FINDER, 1926

Date	Time (sixtieth meridian)	Position: Latitude, north °	′	Position: Longitude, west °	′	Depth
		°	′	°	′	*Fathoms*
Mar. 26	1600	42	35	65	05	45.5
26	1800	42	35	64	38	74.6
26	2000	42	35	64	11	148.5
27	0800	42	45	61	42	773.4
27	1000	42	45	61	22	956.1
27	1200	42	46	61	02	1,301.2
27	1400	42	43	60	40	1,389.9
27	1600	42	43	60	21	1,564.9
27	1800	42	43	59	53	1,625.9
27	2000	42	44	59	31	2,176.6
27	2200	42	44	59	08	2,090.9
28	0800	42	54	57	22	2,411.0
28	1000	42	56	57	03	2,304.6
28	1200	42	57	56	40	2,337.3
28	1400	42	56	55	58	1,949.5
28	1600	42	55	55	55	1,781.4
28	1800	42	55	55	50	2,035.6
29	0800	42	55	52	50	1,768.3
29	1000	43	02	52	41	1,544.8
29	1100	43	10	52	31	1,532.9
29	1200	43	11	52	30	1,520.7
29	1300	43	13	52	29	1,374.9
29	1400	43	16	52	22	1,237.2
29	1500	43	22	52	17	943.3
29	1530	43	24	52	13.5	868.4
29	1600	43	27	52	10	775.7
Apr. 1	1400	42	05	52	37	2,455.6
1	1600	42	18	52	19	2,216.0
1	1800	42	21	52	00	2,009.0
1	2000	42	30	51	39	1,796.5
1	2200	42	33	51	35	1,541.0
2	0800	42	42.5	51	20	1,084.7
2	1000	42	48	50	57	709.5
2	1200	42	54.5	50	34	166.0
2	1400	42	56	50	08	85.0
2	1600	42	56	49	43	944.3
2	1800	42	57	49	31	685.4
2	2000	43	07	49	27	685.4
4	0930	43	29.5	49	33.5	43.0
4	1000	43	29.5	49	27.5	48.6
4	1030	43	29	49	22	69.0
4	1100	43	29	49	15	85.3
4	1130	43	28.5	49	09	120.7
4	1200	43	32	49	07	572.8
4	1300	43	41	49	03	544.7
4	1400	43	50	48	58	143.0
4	1500	43	58	48	54	120.7
5	0800	43	47	49	16	402.0
5	1000	44	04	49	11.5	157.2
5	1200	44	02	49	14	44.3
5	1400	43	45	49	19	381.8
5	1600	43	27	49	20	202.0
5	1800	43	15	49	16	382.0
8	1030	43	47	50	24	33.7
8	1200	43	44.5	50	16	29.0
8	1300	43	41	50	02	33.0
8	1400	43	37	49	51	36.0
8	1500	43	33.5	49	39	38.3
8	1600	43	29	49	27	59.1
8	1700	43	38	49	20	224.0
8	1800	43	45	49	13	502.0
9	0800	43	47	48	39	1,347.3
9	0900	43	52	48	21.5	1,676.0
9	1000	43	58	48	14	1,789.0
9	1100	44	04	48	17.5	1,768.3
9	1200	44	13	48	20	1,752.1
9	1300	44	18	48	08	1,894.5
9	1400	44	14	48	01	1,874.7
9	1500	44	11	47	50.5	2,073.4
10	1200	43	15	48	21	1,680.0
11	0800	42	55	51	19	321.3
11	1000	42	55	51	26	723.3
11	1200	43	00	51	58	1,403.8
11	1400	43	02	52	25	1,626.0
11	1600	43	06	52	52	1,809.0
11	1800	43	08	53	22	1,919.6
11	2000	43	13	53	46	2,205.2
Apr. 11	2200	43	14	54	03	2,337.3
12	0800	43	13	53	46	2,299.0
12	1000	43	13.5	55	20	2,310.3
12	1200	43	08	55	30	2,310.3
12	1400	43	09	55	42	1,908.5
12	1600	43	07	55	56	1,929.0
12	1800	43	08	56	13	2,047.0
12	2000	43	08	56	33	2,018.3
12	2200	43	08	56	47	2,047.0
13	0800	43	20	58	34	1,771.2
13	0900	43	22	58	47	1,564.8
13	0930	43	22	58	53	1,564.8
13	1000	43	22	59	00	1,289.0
13	1030	43	22.5	59	06	1,386.4
13	1100	43	24	59	11	1,217.0
13	1130	43	25	59	17	1,172.4
13	1200	43	27	59	25	1,153.4
13	1330	43	31	59	44	774.[illegible]
24	0830	43	53	61	17	31.[illegible]
24	0900	43	51	61	10	36[illegible]
24	0930	43	50	60	54	25.[illegible]
24	1000	43	48	60	50	23.5
24	1030	43	46.5	60	45	30.1
24	1100	43	45	60	46	32.2
24	1200	43	39	60	20	42.6
24	1300	43	38	60	11	55.3
24	1400	43	34	59	52	674.0
24	1500	43	30	59	37	1,302.8
24	1600	43	26	59	22	1,381.2
24	1700	43	23	59	12	1,443.2
24	1800	43	21	59	03	1,838.1
24	1900	43	18	58	53	1,689.2
24	2000	43	06	58	43	2,011.7
24	2100	43	03	58	31	1,992.2
24	2200	43	00	58	18	1,944.4
25	0800	43	04	56	37	2,072.7
25	0900	43	04	56	30	2,072.7
25	1000	43	04	56	26	2,099.3
25	1100	43	04	56	16	1,972.9
25	1200	43	07	56	09	2,052.0
25	1300	43	07	55	52	2,052.0
25	1400	43	04	55	38	1,954.0
25	1500	43	04	55	22	2,311.5
25	1600	43	03	55	05	2,248.3
25	1700	43	03	54	53	2,225.5
25	1800	43	02	54	48	2,225.5
25	1900	43	02	54	39	2,225.5
25	2000	43	00	54	30	2,255.9
25	2100	42	59	54	21	2,322.7
25	2200	42	58	54	12	2,392.7
26	0800	43	02	53	14	2,008.0
26	1000	42	55.5	52	59	2,008.0
26	1100	42	58	52	58	2,008.0
26	1200	43	02	52	50.5	2,008.0
26	1300	43	07	52	46	1,842.1
26	1400	43	11	52	39	1,680.8
26	1600	43	18	52	34	1,563.0
26	1630	43	21	52	31	1,518.4
26	1700	42	23	52	29	1,436.4
26	1730	43	25	52	26.5	1,273.0
26	1800	43	28	52	24.5	1,220.6
26	1830	43	29	52	23	1,058.8
26	1900	43	31	52	21	954.2
26	1930	43	33	52	18	940.7
26	2000	43	34	52	18	940.7
28	0800	43	53	51	20	41.3
28	0900	43	43	51	18	37.8
28	1000	43	33	51	15	48.8
28	1100	43	22	51	13	59.5
28	1200	43	13	51	10	191.2
28	1300	43	02.5	51	06.5	771.3
28	1400	42	59	51	04	811.1
28	1500	42	50	51	10	943.1
28	1600	42	43	51	17	1,087.2
28	1700	42	41	51	19	1,243.7
28	1800	42	32	51	28	1,383.1
28	1900	42	24	51	32	1,501.2

Soundings as recorded with the sonic depth finder, 1926—Continued

Date	Time (sixtieth meridian)	Position: Latitude, north	Position: Longitude, west	Depth
		° ′	° ′	*Fathoms*
Apr. 28	2000	42 22	51 34	1,582.3
28	2100	42 17	51 39	1,723.9
28	2200	42 08	51 46	1,759.9
29	0800	41 27	51 02	2,246.9
29	0900	41 24	50 49	2,442.6
29	1000	41 20	50 37	2,276.1
29	1100	41 13	50 25	2,276.1
29	1200	41 06	50 16	2,044.8
29	1300	41 06	50 16	2,044.8
29	1500	41 21	50 16	1,921.4
29	1600	41 27	50 16	2,012.8
29	1700	41 34.5	50 16	2,012.8
29	1800	41 45.5	50 16	2,012.8
29	1900	41 47	50 17	1,964.5
29	2000	41 56	50 17	1,878.6
29	2100	42 06	50 17	1,742.4
29	2200	42 08	50 17	1,701.5
29	2240	42 14	50 17	1,627.3
29	2300	42 17	50 17	1,596.0
29	2320	42 20	50 17	1,426.4
29	2340	42 23	50 17	1,432.8
30	0000	42 25	50 17	1,432.8
30	0020	42 27.5	50 17	1,322.3
30	0040	42 29	50 17	1,290.3
30	0800	42 38	49 45	1,136.6
30	0900	42 41	49 39	1,170.5
30	1000	42 38	49 36	1,200.0
30	1100	42 34	49 29	1,344.9
30	1200	42 30	49 24	1,407.1
30	1300	42 28	49 20	1,437.2
30	1400	42 26	49 16	1,480.4
30	1500	42 22	49 10	1,522.2
30	1600	42 17	49 05	1,576.3
30	1700	42 12.5	48 56	1,602.3
30	1800	42 11	48 20	1,618.6
30	1900	42 10	48 49	1,639.5
30	2000	42 10	48 46	1,639.5
May 1	0800	41 49	48 14	1,912.4
1	0900	41 43	48 11	1,982.7
1	1000	41 37	47 59	1,846.5
1	1100	41 30	47 47	2,033.3
1	1200	41 27	47 44	2,147.5
1	1300	41 22	47 35	2,130.2
1	1400	41 16	47 25	2,170.2
1	1500	41 09	47 15	2,182.0
1	1600	41 08	47 11	2,225.9
1	1700	41 15	47 14	2,205.4
1	1800	41 25	47 16	2,175.6
1	1900	41 35	47 18	2,145.0
1	2000	41 44	47 20	2,175.6
1	2100	41 53	47 23	2,175.6
1	2200	42 03	47 25	2,175.6
2	0800	42 56	47 37	1,805.5
2	0900	42 57	47 41	1,945.1
2	1000	42 58	47 45	1,846.5
2	1100	42 59	47 50	1,846.5
2	1200	43 00	47 54	1,825.7
2	1300	43 00	47 57	1,876.0
2	1400	43 01	48 01	1,876.0
2	1500	43 02	48 05	1,746.5
2	1600	43 02	48 09	1,746.5
2	1700	43 03	48 12	1,705.7
2	1800	43 03	48 14	1,705.7
2	1900	43 04	48 15	1,669.1
2	2000	43 05	48 22	1,602.3
3	0800	42 45	49 37	1,145.1
3	0900	42 47	49 40	1,136.6
3	1000	42 49	49 43	1,233.5
3	1100	42 51	49 43.5	1,105.5
3	1130	42 54	49 45	1,098.0
3	1200	42 52.5	49 44	1,091.8
3	1230	42 56	49 46	1,008.4
3	1300	42 57	49 46	990.0
3	1330	42 52	49 46.5	926.6
3	1400	42 59	49 47	896.9
4	0800	43 25	50 17	35.6
4	0900	43 26.5	50 18	38.1
May 4	1000	43 30	50 13	34.3
4	1100	43 30	50 00	34.3
4	1130	43 30	49 54	37.3
4	1200	43 30	49 47	36.3
4	1230	43 30	49 41	37.3
4	1300	43 30	49 35	36.3
4	1315	43 30	49 31	37.3
4	1330	43 30	49 27	50.2
4	1345	43 30	49 24	48.6
4	1400	43 30	49 21	52.7
4	1415	43 30	49 18	70.5
4	1430	43 30	49 14	125.9
4	1445	43 30	49 12	211.3
4	1500	43 31	49 10	422.4
4	1600	43 34	49 07	281.5
4	1700	43 40	49 05	414.8
4	1730	43 42	49 04	441.4
4	1800	43 43	49 02	441.4
4	1900	43 44	48 59	402.2
5	1000	43 37	48 06	1,871.7
5	1100	43 38	48 02	1,916.8
5	1200	43 32	48 14	1,770.1
5	1300	43 28	48 25	1,602.3
5	1400	43 26	48 28	1,602.3
5	1500	43 24	48 32	1,497.3
5	1600	43 21	48 41	1,393.5
5	1700	43 16	48 54	1,032.2
5	1800	43 07	49 02	1,003.9
5	1900	43 01	49 12	800.4
5	2000	43 02	49 26	687.0
27	0800	42 30.5	50 14	1,634.1
27	1000	42 20	50 11	1,634.1
27	1100	42 19	50 15	1,650.3
27	1200	42 17	50 26	1.634.1
27	1300	42 12	50 32	1,721.0
27	1400	42 19	50 42	1,618.0
27	1500	42 25	50 53	1,516.2
28	0800	42 13	50 15	1,814.7
28	0900	42 13	50 13	1,814.7
28	1000	42 13	50 12	1,814.7
28	1100	42 14	50 09	1,775.5
28	1200	42 15	50 13	1,814.7
28	1300	42 15	50 13	1,814.7
28	1400	42 16	50 16	1,795.1
28	1500	42 13	50 01	1,835.5
28	1600	42 10	49 48	1,856.3
28	1700	42 06.5	49 32.5	1,775.5
28	1800	42 03.5	49 18	1,646.2
28	1900	42 00	49 02	1,715.4
28	2000	41 57	48 48	1,752.5
28	2100	41 54	48 38	1,771.2
28	2200	41 52	48 26	1,851.8
29	0800	41 28.5	48 23	1,851.8
29	0900	41 26.5	48 23	1,831.0
29	1000	41 25.5	48 23	1.831.0
29	1100	41 24	48 23	1,831.0
29	1200	41 23	48 21	1,810.7
29	1300	41 21	48 21	1,790.7
29	1400	41 20	48 20	1,831.0
29	1600	41 18	48 19	1,831.0
29	1800	41 16	48 18	1,856.3
29	2000	41 13.5	48 16.5	1,992.2
30	0800	41 16	47 54	1,899.6
30	1000	41 13	47 52	1,899.6
30	1200	41 05	48 10	1,835.5
30	1400	40 56	47 56	1,835.5
30	1600	40 59	47 50	1,733.7
30	1800	40 58	47 49	1,790.7
30	2000	40 53	47 47	1,790.7
31	0800	40 47	47 42	1,899.6
31	1000	40 45	47 40	1,921.6
31	1200	40 44	47 38	1,899.6
31	1400	40 53	47 45	1,856.3
31	1600	41 06	48 02	1,835.5
31	1800	41 21	48 17.5	1,921.6
31	2000	41 33	48 32	1,835.5
31	2200	41 35	48 37	1,877.5

Soundings as recorded with the sonic depth finder, 1926—Continued

Date	Time (sixtieth meridian)	Position				Depth
		Latitude, north		Longitude, west		
		°	′	°	′	*Fathoms*
June 2	0800	41	15	48	30	1,646.2
2	1000	41	15	48	30	1,646.2
2	1200	41	18	48	32	1,662.9
2	1400	41	24	48	25	1,697.5
2	1600	41	16	48	32	1,613.7
2	1800	41	11	48	37	1,662.9
2	2000	41	44	48	33	1,613.7
2	2200	41	42	48	34	1,646.2
3	0800	41	20	48	39	1,835.5
3	1000	41	40	48	43	1,752.5
3	1200	41	35	48	46	1,752.5
3	1400	41	25	48	44	1,810.7
3	1600	41	15	48	40	1,697.5
3	1800	41	04	48	38	1,662.9
3	2000	41	02	48	35	1,697.5
3	2200	41	00	48	30	1,697.5
4	1200	41	06.5	48	26	1,680.0
5	0800	40	57	48	36	1,733.7
5	1000	40	57	48	39	1,752.5
6	0800	41	23	47	50	1,795.1
6	1000	41	28	47	36	2,067.7
6	1200	41	40	47	27	2,094.2
6	1400	41	40	47	27	2,094.2
6	1600	41	36	47	30	2,094.2
6	1800	41	32	47	50	1,944.4
7	1800	41	56	48	49	1,815.1
7	2000	41	55	49	09	1,815.1
8	1000	41	31	48	54	1,907.9
8	1200	41	40	49	09	1,815.1
8	1400	41	52	49	21	1,815.1
8	1600	41	41	49	25	1,613.7
8	1800	41	35	49	38	1,690.6
8	2000	41	30	49	36	1,791.0
9	0800	41	42	49	10	1,795.1
9	1200	41	52	49	50	1,775.5
9	1400	41	41	49	59	1,733.7
9	1600	41	44	50	25	2,067.7
9	1800	42	07	50	22	1,944.4
9	2000	41	58	50	31	2,067.7
9	2200	41	57	50	29	2,046.8
10	1000	41	53	52	05	2,300.2
23	1300	44	27	63	16	48.4
23	1400	44	23	63	03	87.3
23	1600	44	16	62	36	97.6
23	1800	44	09	62	08	108.6
23	2000	44	02	61	46	77.2
23	2200	43	53	61	14	35.0
24	0800	43	01	59	28	1,733 7
24	1000	42	49	59	23	2,094.2
24	1200	42	37	59	13	2,273.9
24	1400	42	26	59	02	2,372.9
24	1600	42	12	58	50	2,524.7
24	1800	41	59	58	32	2,605.0
24	2000	41	57	58	02	2,524.7
24	2200	42	00	57	35	2,524.7
25	0800	42	02	54	07	2,524.7
25	1000	42	04	54	35	2,564.5
25	1200	42	05	54	01	2,564.5
25	1400	42	05	53	27	2,659.8
25	1600	42	06	52	55	2,748.3
25	1800	42	06	52	51	2,311.5
26	0700	43	06	52	39	1,671.8
26	0800	43	15	52	27	1,326.3
26	0820	43	18	52	24	1,079.0
26	0830	43	19	52	22	1,003.0
26	0840	43	20	52	20	902.3
26	0850	43	22	52	19	864.0
26	0900	43	23	52	16	837.0
26	0910	43	25	52	14.5	801.9
26	0920	43	26	52	13	701.0
26	0930	43	27.5	52	11	632.3
26	0939	43	29	52	10	496.4
26	1200	43	16.5	51	49	632.3
26	1400	43	00	51	23	620.2
26	1445	42	57	51	14	931.4
26	1600	42	50	51	19	1,003.0
26	1800	42	39	51	27.5	1,422.7
26	2000	42	22	51	40.5	1,776.3
27	0800	41	17	50	53	2,449.7
June 27	1000	41	10	50	20	2,311.5
27	1200	41	22	50	20	1,926.3
27	1400	41	36	50	20	2,126.3
27	1600	41	56	50	19	2,021.6
27	1800	42	19	50	18	1,738.0
27	2000	42	29	50	17	1,343.8
27	2030	42	35	50	17	1,116.2
27	2045	42	38	50	17	1,079.0
27	2100	42	40.5	50	17	1,041.7
27	2115	42	44	50	17	1,003.0
27	2120	42	45	50	17	938.9
27	2128	42	46	50	17	659.6
28	0000	42	49.5	50	03	246.9
28	0030	42	51	49	55	250.0
28	0100	42	53	49	47	448.6
28	0105	42	52	49	44	806.0
28	0800	43	02	49	23	701.0
28	0830	43	08	49	23	782.2
28	1000	43	24	49	10	686.2
28	1100	43	34	49	02	1,298.0
28	1115	43	36	49	00	1,308.1
28	1130	43	39	48	59	1,147.7
28	1145	43	41.5	48	59	1,037.8
28	1200	43	43	49	00	824.1
28	1210	43	44	49	00	741.1
28	1215	43	45	49	00	660.8
28	1330	43	45	48	53	1,113.4
28	1400	43	45	48	44	1,264.5
28	1430	43	45	48	37	1,537.6
28	1500	43	45	48	32	1,646.2
28	1600	43	45	48	25	1,697.5
28	1700	43	45	48	09	1,835.5
28	1800	43	45	48	04	1,877.5
28	1900	43	44	47	51	1,972.9
28	2000	43	44	47	39	2,052.0
28	2100	43	41	47	41	2,052.0
28	2200	43	32	47	49	1,899.6
29	0800	42	18	48	49	1,752.5
29	1000	42	09	48	52	1,752.5
29	1200	41	52	48	29	1,873.0
29	1300	41	49	48	24	1,899.6
29	1400	41	40.5	48	11	2,042.0
29	1500	41	31	47	58	2,042.0
29	1600	41	30	47	55	2,094.2
29	1700	41	24	47	47.5	2,121.1
29	1800	41	15	47	35	2,067.7
29	1900	41	06	47	21.5	2,016.7
29	2000	41	04	47	17	2,067.7
29	2100	40	52	47	13	1.949.2
29	2200	40	39	47	09	1,926.3
30	0800	40	41	49	25	2,218.0
30	0900	40	41	49	43	2,159.4
30	1000	40	42	50	02	2,026.5
30	1100	40	44	50	21	1,958.7
30	1200	40	46	50	38	2,057.0
30	1300	40	47	50	56	2,193.8
30	1400	40	48	51	08	2,498.7
30	1500	40	50	51	30	2,748.3
30	1600	40	51	51	44.5	2,802.1
30	1700	40	52	51	55	2,850.0
30	1800	40	54	52	12	1,900.5
30	2000	40	56	52	42	2,753.0
30	2100	40	55	53	05	2,753.0
30	2200	40	56	53	19	2,710.0
July 1	0900	41	15	55	50	2,794.9
1	1000	41	22	56	03.5	2,617.7
1	1100	41	27.5	56	15	2,577.0
1	1200	41	34	56	27.5	2,577.0
1	1300	41	38	56	44	2,577.0
1	1400	41	40	56	57	2,537.0
1	1500	41	42	57	10	2,617.8
1	1600	41	43	57	25	2,577.0
1	1700	41	45	57	40	2,617.8
1	1800	41	47	57	55	2,537.0
1	1900	41	48	58	15	2,537.0
1	2000	41	50	58	30	2,617.8
1	2100	41	52.5	58	45	2,577.0
1	2200	41	54	59	00	2,537.0

ICE OBSERVATION

Edward H. Smith

When the patrol ship, on her first approach to the ice regions, had arrived in the vicinity of the Grand Bank, a request was dispatched to the Canadian Government Radio Station at Cape Race (VAZ) for a summary of the state of the ice up to date. A detailed reply was received giving the position and character of all the ice that had been reported by passing ships, and this is incorporated in the bulletin for this year, heading the list of ice as contained in Table of ice and other obstructions, 1926 (p. 21). The number of bergs south of the forty-eighth parallel is also recorded by months in the table of iceberg anomalies, 1906–1926 (p. 76). The monthly number has been determined by a compilation of all ice reported by passing ships, as well as that sighted by the patrol, care being taken to avoid listing a berg in this area more than once during any one month.

JANUARY

No ice was reported in the western North Atlantic to the best of our knowledge during January. A normal January reports three bergs south of Newfoundland.

FEBRUARY

The first ice report was reported to Cape Race on February 8 (see Table of ice and other obstructions, p. 21), this being slush ice encountered by a ship on the extreme northern part of the Grand Bank near the 100-fathom curve. Eleven other reports were received at various dates throughout the month, all referring to Arctic field ice on the northeastern part of the Bank, except for one report of several small bergs just south of the forty-eighth parallel on February 20. No doubt these were the remains of one or two large bergs, which had survived the summer of 1925, and, being caught in the fields, were naturally the first of the glacial ice to put in an appearance in 1926. It seems reasonable to conclude that only three bergs came south of the forty-eighth parallel during the month of February. Normal conditions would be 12 bergs during February.

MARCH

Thirty-eight reports were received and distributed throughout the month, of ice in the western North Atlantic south of the forty-eighth parallel. Nearly all of these referred to Arctic field ice or to growlers;

only 13 were of the presence of icebergs. Eight of the latter were of bergs classified as large, and one of these was reported three times. The most dangerous bergs reported during the month were a group of four large and three small, reported three different times, as drifting southward more or less together, from the northwestern part of the Bank. The latest report which was probably the direct cause of inaugurating the ice patrol, was contained in the United States Hydrographic Office broadcast of March 20. This dispatch mentioned the positions of four large and three small bergs in the vicinity of

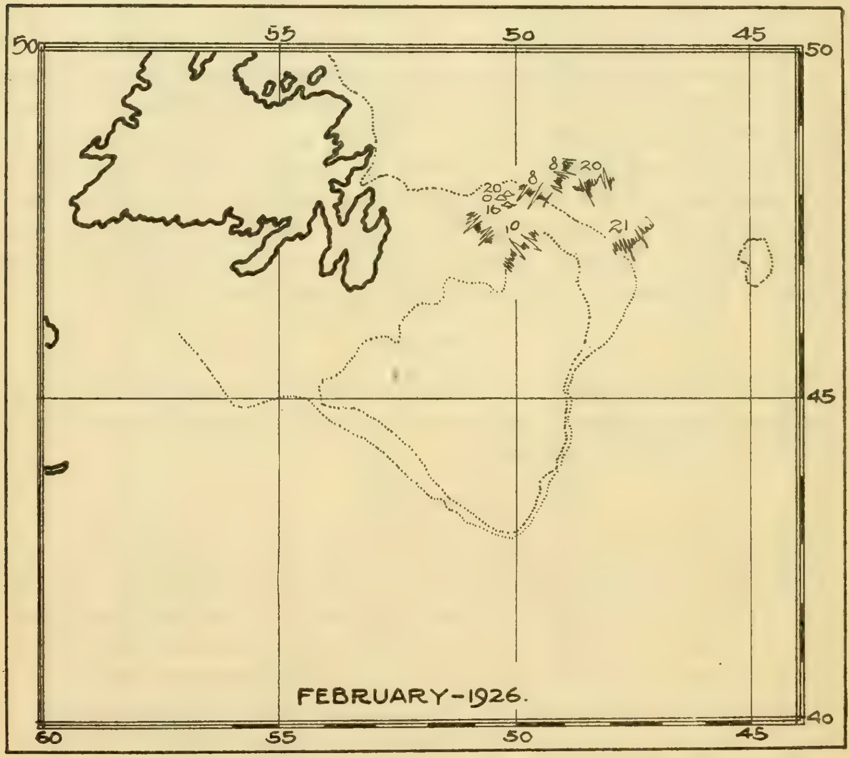

FIG. 10.—February ice map. The position of the first Arctic ice for the season of 1926; the first steamer report from Cape Race was February 8

latitude 45° 15′, longitude 46° 20′. This is about 70 miles offshore of the 100-fathom contour of the Grand Bank, where they might be expected to drift eastward and southward to the northern borders of the Gulf Stream, just where the latter is deflected offshore almost due south of Flemish Cap. No doubt this fate actually befell them as none of these bergs were sighted by the patrol or reported later by passing ships. Probably they finally disintegrated in the warm offshore Atlantic waters, as they drifted northeastward, away from the steamer lanes. Another large berg drifted southward to latitude 45°, about 30 miles seaward of the slope where it was sighted on

March 26. Since no further reports were received, we may conclude that it, too, was caught by the inshore invasion of the warm current and eventually carried offshore to the eastward. It might be added that very few ships frequent the regions where the early season ice is most liable to drift (the patrol at the time is watching the southern end of the field ice), so it is difficult to trace the berg movements in as great detail as is possible a month or two later. Four large bergs were reported on the 27th between the 50 and 100 fathom curves on

FIG. 11.—March ice map. Position and kind of Arctic ice sighted and reported in the western North Atlantic for March, 1926. represents field ice. △ represents an iceberg

the northeastern part of the Bank, this closing the list of bergs reported south of the forty-seventh parallel during the month of March. One of the characteristic drifts of icebergs early in the season (before the early part of April) carries them farther offshore to the eastward than is usual later in the year, as explained in previous annual reports. (See Bulletin No. 12.)

The fact that the first bergs are usually observed relatively far off shore between the Grand Bank and Flemish Cap has been ascribed

to the size and extent of the flat ice both as it tends to prevent the bergs from working in shoreward while they are drifting southward past the coasts of Labrador and Newfoundland, and secondly, because of the prevailing westerly gales which in early season exert a tremendous driving force on the fields, within such packs of which the bergs are more or less bound to be caught and deviated. We confidently reiterate a statement made a year or more ago, "The iceberg menace to steamships in the North Atlantic would be greatly diminished or practically disappear, if sea ice did not hamper the Labrador and Newfoundland shelves from February to April every year." The bergs arriving as they characteristically do between the Bank and the Cap, are borne southward on the northern edge of the Gulf Stream and thenceforth their history is quite consistently to drift off to the northeast, paralleling the steamer tracks and rapidly disintegrating.

Field ice during March was present nearly all the time with its main mass hugging closely to the northeastern sector of the Bank as bounded between the 50 and 100 fathom contours. No field ice, it is worth mentioning, was found inshore of the 50-fathom curve, thus leaving the water over the Banks quite open the entire month. This is decidedly less field ice than usual, for in normal years, during this period, the flat ice spreads out to a considerable area over the Newfoundland shelf. The fields on the eastern side were continually being blown offshore by the prevailing westerlies and just as constantly were they being melted as they drifted out into the deep water off the shelf. Many reports on the seaward side of this ice mentioned the presence of growlers scattered here and there over a considerable frontage. The growlers evidently were nothing more than those parts of the Arctic pans which had become rafted and frozen together, and being of a mass bulkier than the flat ice was able to survive it by a matter of days only. Some of the flat ice succeeded in drifting southward to an extreme point as noted on March 23 in latitude 43° 45′, longitude 48° 07′. Summarizing for the month, we estimate that there were a total of 15 separate and distinct bergs south of the forty-eighth parallel during the period, and this is about one-half the number of bergs that usually drift south during the month of March. The field ice was confined to the northern part of the Banks, along the edge of the slope, and driven southward by the winds to the southerly position as noted on the 23d instant. The amount this year is considered below that present in a normal year, but more than prevailed in either 1924 or 1925.

APRIL

The reports for the month of April began to come in on the second day when a berg was sighted by a ship well to the eastward of the

Banks on the inshore edge of the Gulf Stream. This berg was not reported again, and inasmuch as our records for previous seasons indicate quite consistently that ice in such a position drifts northeastward more or less parallel with the steamer tracks, we felt confident such a history occurred in this case. On the 8th three small

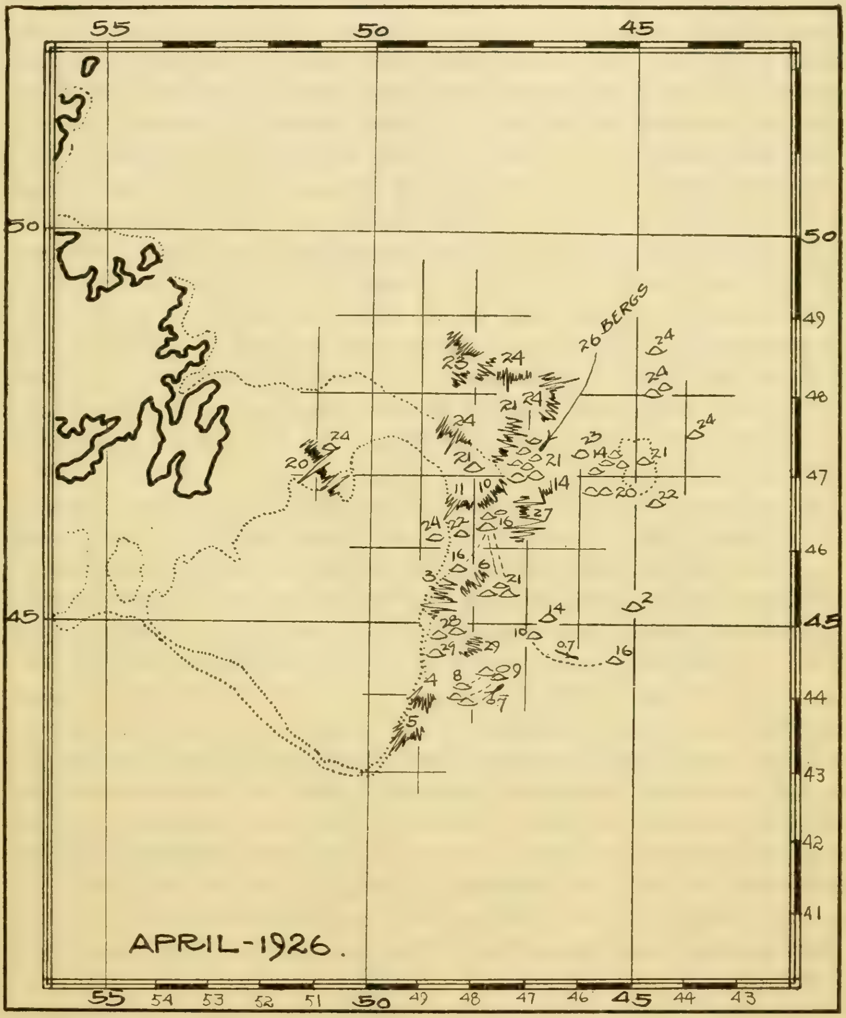

FIG. 12.—April ice map. Position and kind of Arctic ice sighted and reported in the western North Atlantic for April, 1926. represents field ice. △ represents an iceberg

bergs were reported on forty-fourth parallel, 40 miles offshore of the continental shelf and the next day the patrol located this group, it having drifted northeastward at the rate of 0.7 knot per hour. The bergs were really so small that they were nearly the size of growlers and it is believed they became entirely melted by the 12th. This

position on the forty-fourth parallel, it might be added, was the farthest south recorded for any berg during April. Looking northward on the map for April, we note that four bergs were reported the 14th on the western edge of Flemish Cap. Two bergs were just inside the 100-fathom curve to the westward on the Grand Bank and seven bergs were scattered on an east and west line between the Bank and the Cap. A berg was reported on the 16th close in to the Bank slope, and of all the glacial ice recorded to date this berg was regarded from its position as being most liable to drift southward and menace the southern routes. This fear proved groundless as nothing more was heard of its career. A berg was reported offshore on the 10th, and again on the 14th, in each instance located without much doubt in the northern edge of the Gulf Stream drift. A second report from this locality of a small berg probably referred to the one previously mentioned on the 10th; its new position would accord with the oceanographic circulation and indicated a rate of drift of 0.7 knot per hour. Three bergs between the forty-fifth and forty-sixth parallels about 50 miles eastward of the slope were reported on the 21st and it is believed that they were the same as two previously recorded on the 16th, which would account for a drift almost due south at the rate of 0.4 knot per hour.

Clear weather set in the 22d on the northern routes and for a period of the next three or four days a considerable number of bergs were reported which greatly augumented the list for April. For example the most populous distribution existed on the 100-fathom curve in latitude 47° where one ship sighted 26 bergs and an extensive ice field. These bergs with the addition of a few scattered ones were continually being reported by passing vessels the 23d to 26th instant. On the 28th and 29th three or four bergs of this aforementioned original group were reported south to the extreme limit for the month, excepting three small bergs on the 8th, on the east edge of the Bank in latitude 44° 45′. One berg only was reported in on the shelf, but its position was well to the northward in latitude 47° 20′ longitude 50° 45′. It is worth remarking that records show only about one-eighth or one-ninth of the total number of bergs south of Newfoundland ever succeed in drifting south of the Tail of the Grand Bank.

We ought not to fail to mention the behavior and distribution of the field ice for April. It was present during the entire month on the northeastern slope of the Banks north of the forty-sixth parallel, but due to the fact that there were few ships passing through this zone the presence of the fields were not recorded often. Whenever a ship crossed this vicinity, however, we were quite certain to receive an ice report. The patrol recorded what proved to be the southernmost invasion of the Arctic sea ice for the current year, the field

being sighted in the form of an attenuated tongue stretched southward along the edge of the slope to latitude 43° 23′ on April 5. Its movement between the 4th and 5th was at the rate of 1 knot per hour parallel to the slope, while three days after, during the interim of which a westerly gale had prevailed, no vestiges were to be found except an occasional growler here and there well offshore of the slope. On the 29th we received a report from the master of the sealing steamer *Terra Nova* (Captain Kean), containing a general account of field ice conditions northward along the east coast of Newfoundland. He stated having found the main pack about 40 miles north of Funk Island in the early part of March where also were loacted the seals. Northerly winds prevailed, driving the ice into the rivers and bays along the coast, more or less blocking the entire coast line southward to Bonavista Bay. Captain Kean had completed the catch by the 20th and was leaving the western edge of the pack, then about 100 miles east-northeast of Cape Race. The field ice this year, he stated, was much nearer land than last year and there did not appear to be a great quantity of bergs. Field ice was reported off and on pretty nearly throughout the entire month's span and its eastern limits, to the northward, coincided very closely with the forty-seventh meridian. The last few days of the month (the 28th and 29th), field ice emerged again southward to within 80 miles of its farthest southern point described April 5. On April 29 a patch was reported in latitude 44° 30′, longitude 48°.

Summarizing for the month we estimate that there were a total of 58 bergs south of the forty-eighth parallel, the normal number being 78; this is approximately 33 per cent less than the average.

MAY

The reader will recall that during April a group of three bergs had been reported in an extreme southerly position on the east side of the Banks, latitude 44°, on the 8th instant. No bergs had been reported so far south as this throughout the month until the last few days, the 28th and 29th, when a group of three bergs were sighted by a passing steamer between the forty-fourth and forty-fifth parallels in the deep water just off the slope. The first report for the month of May, which indicated that the bergs were on the move to the southward, was that of the 2d instant when a berg was sighted in latitude 44° 10′ on the east side of the Banks. The patrol ship at the time was a few miles southeast, hove to in a northwesterly gale but the position of this berg was regarded with considerable interest as it was the second one for the year, apparently, which was in a critical position to drift southward of the Tail. Accordingly as soon as the gale abated we commenced efforts to locate it and so on from the 3d to 11th instant we carried on a search estimating the probable drift from day

to day. The work, however, was greatly handicapped by continual encounters with fog and low visibility which no doubt prevented the patrol from making contact with this iceberg. Throughout this period of eight days reports of bergs to the northward were continually being received and also information regarding the position of isolated fields of ice on the eastern side of the Bank, but none southward of the forty-sixth parallel. Other patches of field ice were reported between

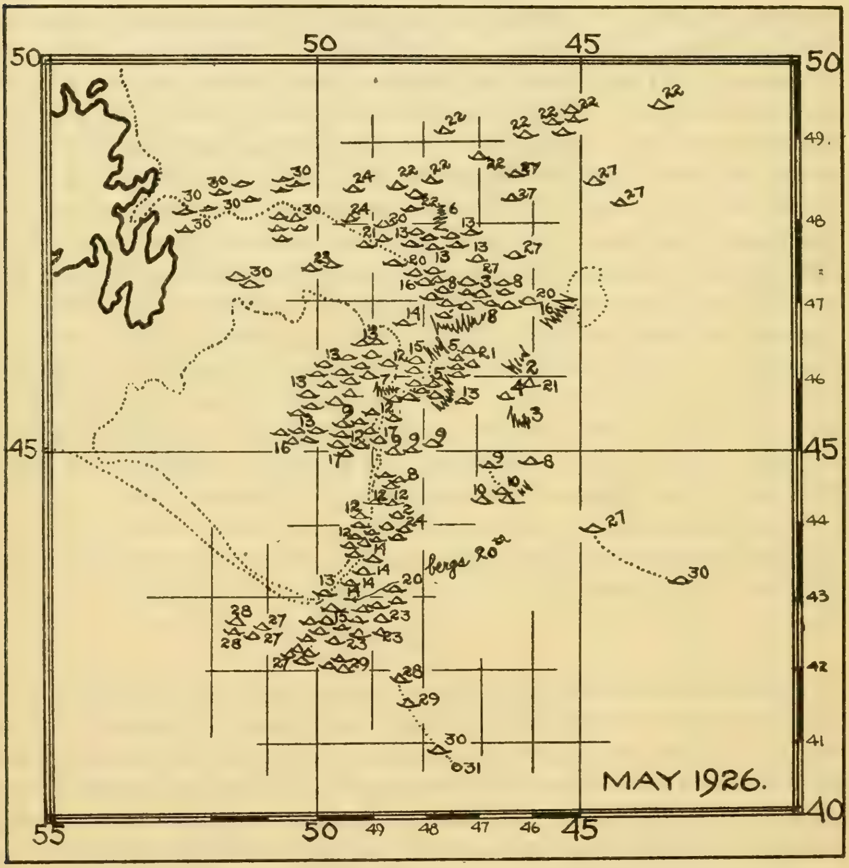

Fig. 13.—May ice map. Position and kind of Arctic ice sighted and reported in the western North Atlantic for the month of May, 1926

the Grand Banks and Flemish Cap. On the 5th, 8th, 9th, and 12th days in May bergs were reported in groups as large as three to five in number all the way from the forty-fifth parallel southward to latitude 43° 30′ just eastward of the edge of the Bank. The reports were not in great detail on account of fog enveloping this entire area, but it was not difficult to observe in general that the bergs were commencing to get farther south and were drifting in their usual path toward the Tail of the Bank. A respite from foggy weather came at last on

May 13 and 14, and these two days of excellent visibility permitted the patrol ship to locate a total of 21 bergs which were scattered along the eastern side of the Bank from the forty-third parallel northward to latitude 44° 15′. This was really the first period of serious scouting

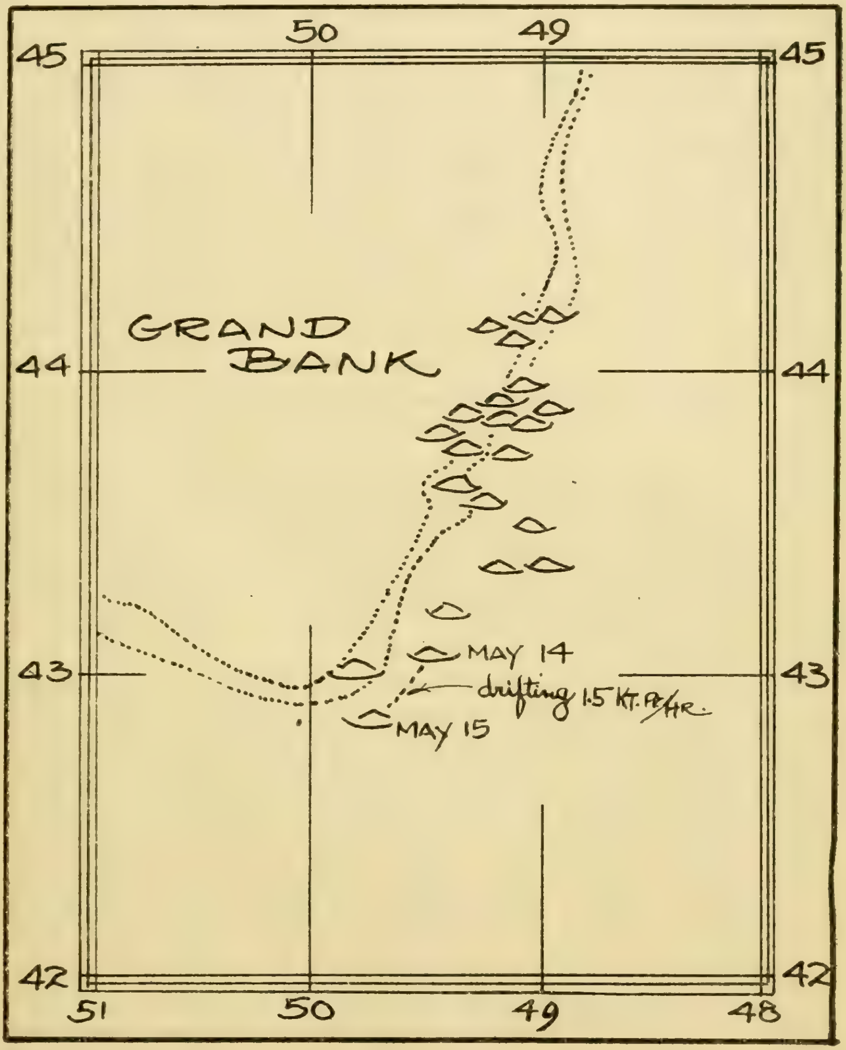

FIG. 14.—Bergs sighted by the patrol May 13–14. These were the vanguard of a greater number than usual which drifted south of the Bank in May

which the patrol had been able to accomplish so far this year and these dates of the 13th and 14th may be accepted quite confidently as marking the initial invasion of glacial ice, during 1926, into relatively low latitudes. Moreover, it was believed that a berg located on the very tip of the Tail of the Bank on both of these dates, was one

and the same as reported in a dispatch of the 22d instant and as previously discussed. It remained grounded in this spot; depth of water 43 fathoms, for the next four or five days.

The clearing of the fog on the 13th and 14th instant was due to the northward spread of the summer time North Atlantic high pressure area, which accordingly caused a shift of the wind from the prevailing southerly direction to the northwest quadrant. Not only was this clear weather a great boon to the patrol, enabling it to accurately fix the position of the southerly bergs, but also it permitted steamships to the northward which were crossing the continental slope, east and west bound from Canadian ports, to sight numerous bergs in those regions. There was a total of approximately 102 reports concerning the position of bergs north of the forty-fifth parallel submitted by passing steamers to the patrol vessel in order that we might collect and rebroadcast such information to other ships. In fact, during this period of nine days there were received about two-thirds of the reports for the entire month, all of which concerned the location of bergs distributed from the forty-fifth parallel northward to the forty-eighth parallel. The area containing the most abundant amount of ice was between the forty-sixth and forty-eighth parallels on the eastern side of the Bank. Nearly all the aforementioned ships were using track E, and the distribution of bergs as shown from the map indicated this populous belt extended northeast and southwest from just inshore of Flemish Cap southwestward in over the Bank to an extremely western position of longitude 50° 20′.

The duration of clear weather was comparatively short, for on the 15th instant about noon the fog shut in again with earnestness. This illustrates the general behavior of weather conditions during the spring of the year and with which the patrol is obliged to contend. Prevailing atmospheric circulation supplies a more or less constant indraft of warm moisture-laden winds which blow from the southerly quarter and the Gulf Stream. These winds, reaching the relatively cold water which surrounds the Banks, are cooled and their moisture is precipitated mostly in the form of fog interspersed with rain. Occasional interruptions come in the form of high-pressure atmosphere phenomena which usually bring clear weather for a short time only, so that the patrol has come to expect on the average a period of four to seven days of thick weather followed by two or three days of clear visibility and then a resumption of fog. Before the fog rolled in on the 15th the patrol vessel had time to identify one of the southerly bergs as observed the day previously which was then drifting 1.5 knots per hour southwestward past the Tail. Here then was a potential menace which was probably drifting to the westward, and from the current map probably on to the southwest slope;

but a small deviation in the current might tend to transport this ice offshore, where it was liable to be turned to the eastward and eventually appear in a very unsavory position immediately northward of the steamer lanes. The current map, which had been compiled on board April 29 to May 5 (fig. 49, p. 109), about two weeks previously, indicated, however, that the probable tendency for this ice was inshore to ground on the Bank.

Fog, as we have just remarked left nothing else for us to do but wait patiently near the Tail of the Bank and somewhat to the southward, blind to the movement of the 21 bergs, but hoping any day to get an opportunity for clear weather and another search. The fog continued to prevail for five days, but on the expiration of the third, we decided to remain inactive no longer. It was thought that failing to follow this ice by means of actual contact each day, the next best proposition lay in compiling on board, as soon as possible, a map showing the current in this critical region which was now infested with several bergs. The ice patrol ship, therefore, May 18 to 20, was occupied in making a current survey of these fog-bound waters south and southwest of the Tail—the so-called critical area.

The fog cleared on the 20th instant and also the same day the oceanographic work was completed and the course and velocity of the currents were mapped. As a result of this work is discussed under the section of oceanography it will not be mentioned in detail here except to remark that the Labrador current flowed westward from the Tail to latitude 42° 34′, longitude 51°, and from this point one branch swept westward flooding the slope of the Bank, while offshore a branch bent sharply back 113° through latitude 41° 55′, longitude 50°. A natural inquiry for the reader to make is, "What was the subsequent behavior of the large group of 21 bergs which was located just north of the Tail on May 14?" Since none of this ice was sighted in the critical area southwest of the Tail during the oceanographic survey, it is believed several of the bergs were detained around the slopes of the Bank, and that most of them drifted offshore into the northeast set, with practically no ice following tracks southward past the Tail. It is most likely that the inshore edge of the warm counter current which we have just described on the current map, transported the majority of these bergs northeastward finally to melt them away from the steamer lanes. It is unfortunate that the patrol ship had no opportunity during the month to search this locality in order to corroborate such a belief.

During the period May 15 to 20, reports from ships traversing the regions to the northward were not so numerous as earlier in the month yet it ought to be remembered that these waters were en-

shrouded in fog as well as where the patrol ship was further south. In spite of the low visibility on the northern routes, however, the bergs continued to be reported, which is pretty good evidence that they must have been quite plentiful, and many of the reports mentioned passing ice close aboard.

Just about nightfall on the 20th of May the steamship *Tiger* reported the position of 10 icebergs to the patrol, on the forty-third parallel, and about 25 miles east of the Tail. The patrol at the time was only a short distance to the southward finishing the last of the oceanographic stations and inasmuch as this ice was in a position from which it was liable to drift farther south the patrol laid plans to locate these bergs the next morning. Fortunately the 21st, 22d, and 23d of May were days of clear weather and this permitted us to determine the position of 26 bergs distributed around the Tail and as far north as 43° 20′. The distribution of this group is shown on the accompanying sketch. There were no large bergs found and it was quite striking to observe that they were all about the same size and fairly well collected together. It is also worth remarking that none of these bergs were identified as any of the former group sighted on the 13th and 14th instant, nor would such a coincidence agree at all with the set and velocity of the currents which had been flowing in this interim of about one week. Several of the bergs were carefully watched as to geographical position and it was quite plainly observed that those farther offshore of the slope were being turned or retarded in the dead water which from the current map existed there. This movement is further illustrated on Figure 15, page 65. A regard of the current map together with the positions of the bergs convinced patrol officials that this ice constituted a serious menace to the present North Atlantic lane routes and it was believed that within the space of 7 to 10 days many of the bergs would be on, or uncomfortably near, the steamship tracks. It was deemed of utmost importance, with such information at hand, to advise Washington immediately to shift the tracks farther south.

Reports regarding the position of bergs to the northward continued to be received by the patrol, and after May 15 the shift from track E to Cape Race track, caused numerous bergs to be sighted in the more northerly latitudes of 48° and 49° and also longitudes farther west, viz, 50° and 51°. (See fig. 13, p. 60.)

The patrol was engaged in effecting the relief between its two ships the 24th and 25th and on the 26th instant, when we had returned to the vicinity of the southern bergs, south of the Tail (see fig. 15, p. 65) a dense fog was encountered. A steamer passing close to us on this day reported having narrowly missed a berg and growler, and a brief light up during the afternoon permitted us to sight what was believed to be the southernmost ice. It was foggy at this time, it must

be remembered, and no great area could be searched nor could the bergs be definitely located, so under such conditions there was bound naturally to be a feeling (realizing as we did the direction and velocity of the current), that there was a very good possibility of scattered bergs drifting in widely distant positions. The problem seemed to be without solution, however, as long as fog continued to envelop these waters. Clear weather came on the 27th instant and the patrol was able to get in touch with some of the bergs of the group last plotted in positions May 21 to 23. (See fig. 15.) A group of five bergs were kept in sight for two days, the 27th and 28th instants, and were subsequently reported by passing steamers on

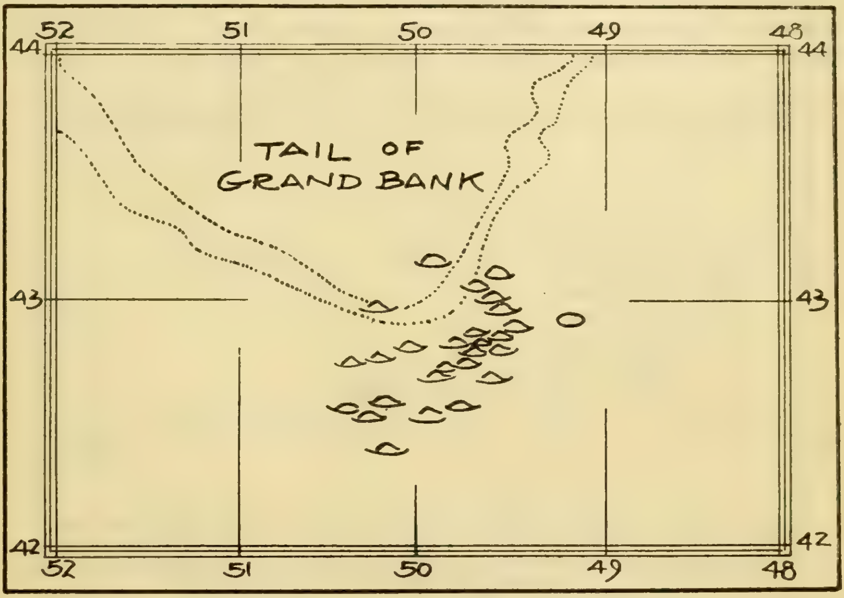

FIG. 15.—Bergs sighted by the patrol May 22 and 23. This was not the same group located May 13–14. (See fig. 14, p. 61.)

May 29, June 1, 2, and 3. Figure 16 is inserted on page 66 in order that the reader may follow the relative positions and career of this ice. The northern bergs of the group were, according to the current map, on the inshore edge of the offshore current but the three southern bergs, that is, those farthest offshore, were in the current proper, drifting 100° at rate of 0.5 knot per hour. This agreed very well with the current as calculated there May 18 to 20, and it showed, furthermore, the manner in which the offshore bergs in the stronger current outdistanced those only a matter of 5 miles or so farther inshore.

Here is an excellent example of the appreciable difference possible in the movement of the water between two places located relatively

close together in this critical area south of the Tail. While we were lying near the bergs on the 28th instant observing their behavior, a report of a berg in latitude 41° 50′, longitude 48° 23′ was received and this being only 20 miles north of the westbound track and also the southernmost ice, the patrol immediately headed toward the position at full speed. Twice during the afternoon the same ice was reported by other vessels in about the same position at which we arrived near nightfall. The berg was not very large and was thought to be one of that group originally sighted on May 14 just north of the Tail for its position could under such conditions be attributed to the course and velocity of the current. We followed this berg for three days, the 29th, 30th, and the 31st (see fig. 17, p. 67), and inasmuch as it was unusually far south position for ice, during these three days of disintegration it merits more than passing interest.

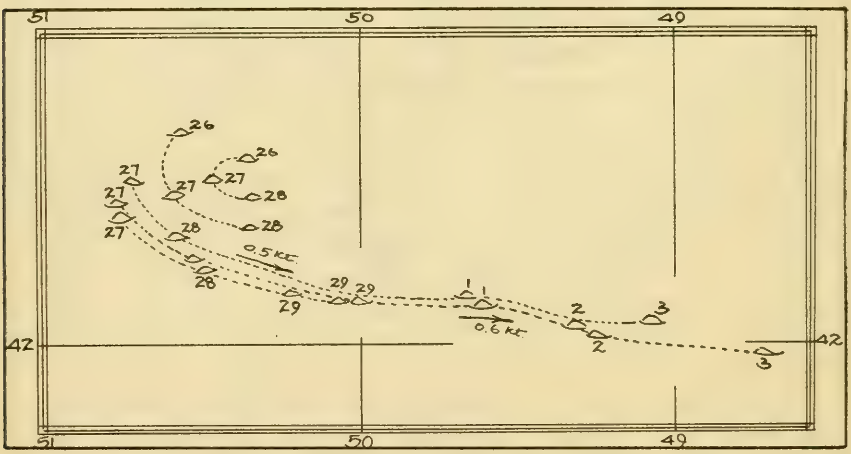

FIG. 16.—The behavior of a group of five bergs May 26 to June 3, drifting on the northern edge of the Gulf Stream south of the Grand Bank

At 5.30 a. m. on the 29th we sighted the berg bearing 210°, distance 4 miles, and approached nearby. It was approximately 150 feet long and 60 feet high. A light sea was running from the northeast, the sky was overcast the entire day, and the temperature of the water was 46°, with the air 47°. We fired 18 to 20 shots with the 6-pounder after gun which brought down considerable ice. In the afternoon two mines containing about 238 pounds of T. N. T. were exploded beneath the surface while suspended by a rope from the berg. The mines tore off several large growlers, but did not cause any great amount of damage. On May 30 during the 4 to 8 a. m. watch a northeasterly swell began to make up which continued quite "lumpy" all day. We came up close to the berg about 2.45 in the afternoon and it was apparent to everyone on board that it had been reduced to one-half its size of yesterday. Many growlers were calving off

and the rate of disintegration was rapid. The sea-water temperature did not change from that of the 29th until about 8 o'clock in the afternoon when it rose to 55° as we drifted across the "cold wall." The sky was overcast similar to that of the preceding day. Constant

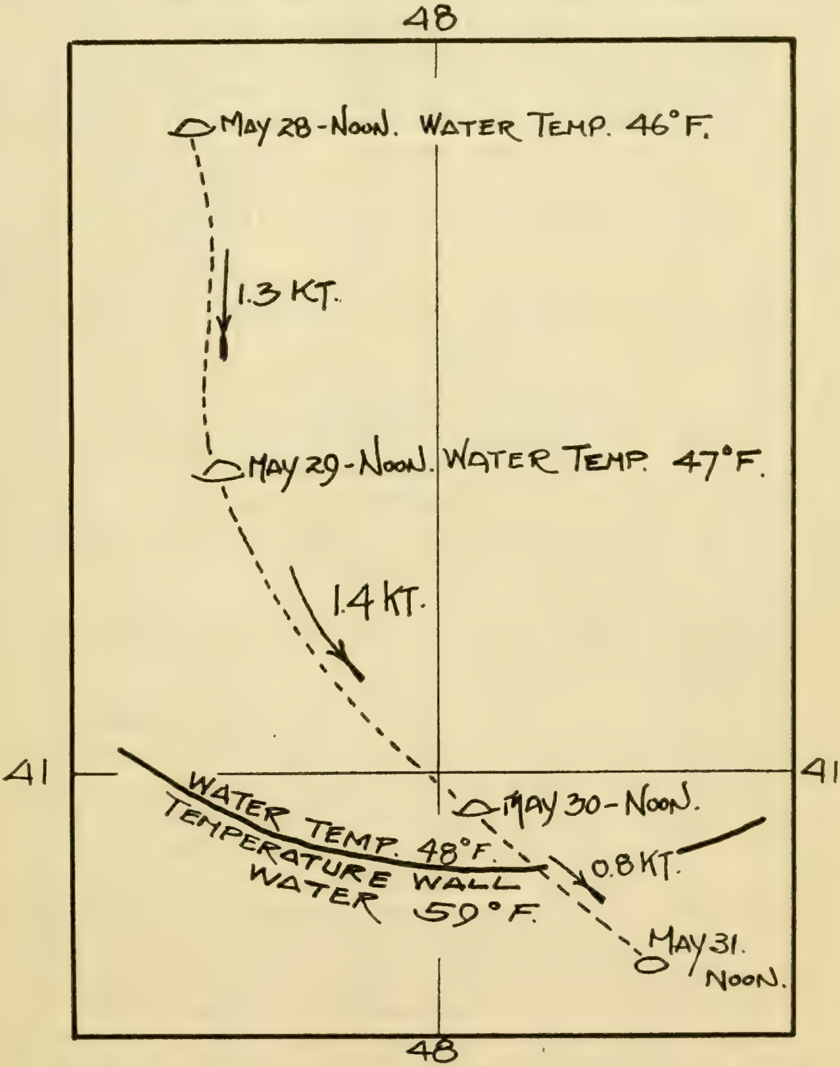

FIG. 17.—The drift and position of final disintegration of a berg followed by the patrol, May 28-31, 1926

touch was kept with the berg during the night and on May 31, at 8 o'clock in the morning, it was no larger than a good size ship's boat. The water temperature had remained constant and the northeast swell continued. The rapid rate of disintegration described herewith is attributable mainly to the appreciable swell and sea which in the

24 hours entirely effaced the berg as a menace to navigation. This is one of the most rapid cases of disintegration of which the patrol has an account and it brings out one fact quite forcibly, namely, that bergs which attain extremely far south drifts such as near the Azores Islands or near the British Isles can only be accomplished when the berg is floating in a comparatively calm sea.

A summary for the month indicated the following outstanding features: Field ice was not reported south of Newfoundland after the 6th of May. There was this month, however, a great increase over April in the number of bergs reported in the northwestern North Atlantic. The first group of bergs, 21 in number, to arrive at the Tail of the Grand Bank (the gateway to the Atlantic), were sighted by the patrol on the 13th and 14th instant. A great increase in the number occurred during these few days of clear weather when ships on northern routes were also able to sight them. Fog enshrouded the regions from the 15th to 21st but the latter day of which we had a clearing and 26 more bergs were found around the Tail. These it appears quite safe to state were not the same as those sighted the 13th and 14th instants. The 15th to 24th many more bergs sighted between the forty-eighth and forty-ninth parallels by ships which now had commenced to use the Cape Race tracks. May 22 to 31 the patrol kept in touch with the southern and eastern fringe of ice and tracked "strays" to extremely low latitudes, across the west-bound steamer lane.

It is difficult to estimate the number of icebergs south of Newfoundland during the month of May due to the great duplication of reports, but to the best of our belief we state that there were a total of 168, which is 10 per cent more than normal. As for the area south of the Grand Banks we estimate a total of 36 bergs, which is 100 per cent more than normal. This is a great increase in numbers over what was in these regions at any time earlier this year or during any part of 1925 or 1924. The sudden and great increase in numbers, which came with a rush during the month of May, is more or less in agreement with the general character of the atmospheric circulation which prevailed December to March, 1925–26. Conditions were unfavorable towards a normal distribution of ice from October to January, but from January onward atmospheric conditions changed to a diametrically opposite character, which undoubtedly is reflected in a correspondingly sudden increase in numbers of bergs around the Grand Banks for May.

JUNE

The preceding month, May, indicated a total of 168 bergs south of Newfoundland, and 36 south of the Tail of the Bank. The latter figure is twice the normal number and consequently the patrol looked forward with no small amount of conviction that an abnormal num-

ber of bergs would probably continue during June just northward of the steamer tracks.

The first five days were spent following and standing by two bergs both of which drifted across the westbound tracks between meridians 48 and 49, and consequently formed a distinct menace to steamships during this period.

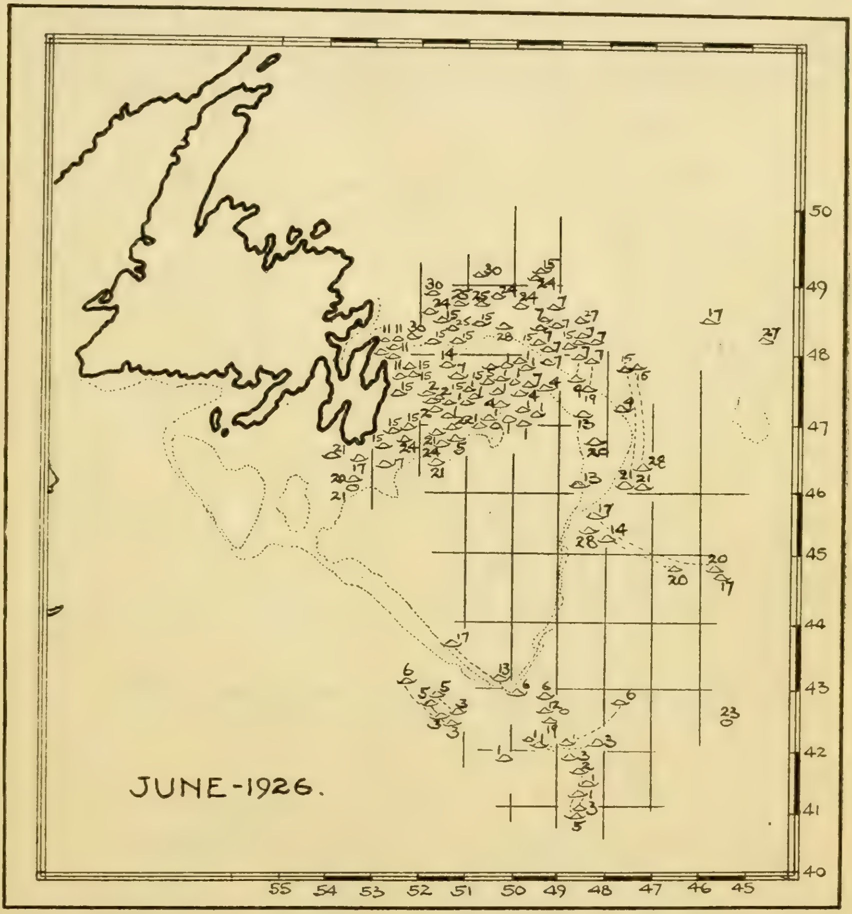

Fig. 18.—June ice map. Position and kind of Arctic ice sighted and reported in the western North Atlantic for June, 1926

The sketch shown herewith gives a good idea of the rate and direction of their drift. It is a drift which is noteworthy for the fact that it lies almost at right angles to the general direction of the Gulf Stream (or what we have conceived or believed to be the prevailing direction of flow) in that particular region. Three oceanographic stations taken somewhat to the northward during the period covered, June 1 to 5, indicated no appreciable set, at least in no way com-

mensurate with the drift rate of the ice, viz., 1 to 1.4 knots per hour If we compare the behavior of these two bergs as to their progressive movement southward between the forty-eighth and forty-ninth meridians, with a distribution of icebergs south of Newfoundland 1900–1926 (see fig. 25), we immediately note the tendency of the ice to attain an extremely far south position takes place between these two meridians of longitudes almost without exception. On June 4 two boats were lowered from the *Tampa* and directed to wire drag berg B, in order that data might be compiled by the ice patrol regarding the draft, volume, etc., characteristic of Arctic icebergs. At

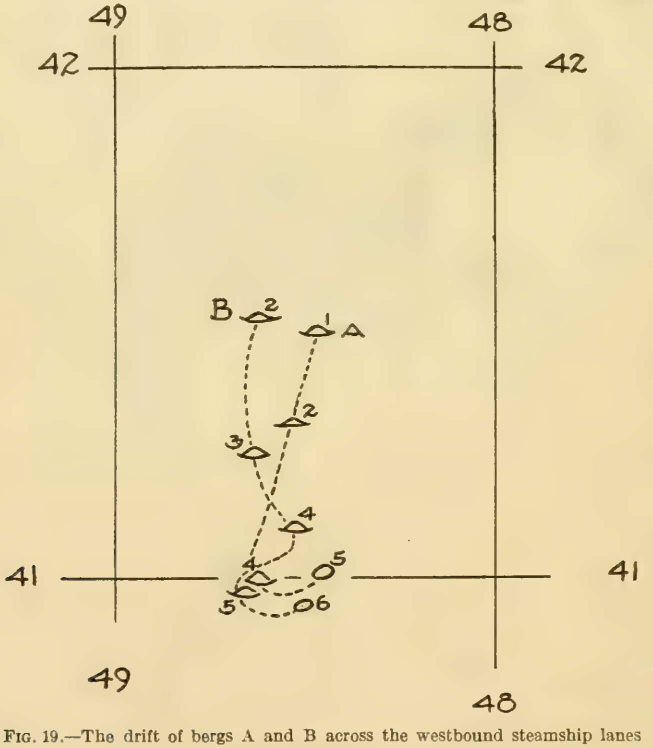

FIG. 19.—The drift of bergs A and B across the westbound steamship lanes June 1 to 6, 1926, inclusive

the same time that the small boats were working on this job measurements as to the exposed surface of the ice were made on the *Tampa* by means of sextant and range finder. The wire dragging operations, unfortunately, were unsuccessful due to the parting of the span which consisted of a condemned sounding machine wire. The above water dimensions were found, however, to be 382 feet long, and an average height above water of 42 feet. This was at 4 p. m. on June 4, latitude 41° 06.5′ north, longitude 48° 27′ west. At 6 p. m. a large square tower on the right-hand side of the berg fell off causing that end to rise, setting up new strains which resulted in cleaving the berg

sharply in twain. The face of the cleavage was as flat as if had been carefully planed to such a surface. Naturally, this increased tremendously the rate of disintegration. The temperture of the water and the state of the sea and weather remained quite the same (see p. 36) for the next five days as that recorded on June 4. At 6 p. m. June 5, 24 hours after the disruption described above, the growler formed by the tower sliding into the sea, had entirely disappeared because of melting. The two small bergs formed June 4 were by the 5th a small berg and a growler in size. At 4 a. m. June 6, latitude 40° 56′, longitude 48° 33′, only 10 hours later, every bit of ice had melted. If we had not actually observed this with careful note, we would have been quite skeptical, I am sure. Such an enormous mass of ice such as we measured on June 4 completely disappearing is hard to reconcile with such an extraordinary survival as recorded of a piece of ice June 25 sighted in latitude 30° 20′ north, longitude 62° 32′ west (see U. S. Hydrographic Office Weekly Bulletin for December 8, 1926.)

The ice regions north of the temperature wall on June 4, which had enjoyed clear weather since May 28, were blanketed in fog which prevailed over these waters until June 13, a period of eight days. After remaining near bergs A and B (see fig. 19) until they had completely melted, the natural procedure was to scout and get in touch with other bergs of the group of 26 seen south of the Tail, May 22 and 23. These bergs, being in the colder waters north of the temperature wall, was thought to be in various, but less menacing positions in this region. We attempted scouting but were rebuffed by the fog pall from June 6 to 13. When we did search these waters (the 14th to 17th instant) northward along the east side of the Bank to the forty-fifth parallel no ice was to be found. Passing steamers located a group of three bergs west-southwest of the Tail which from several consecutive reports indicated they were drifting northwest in a branch of the inshore current, up on to the southwest slope of the Bank. A small piece of ice was reported on the 12th and again on the 19th, not far offshore southwest of the Tail in the dead water, and another berg was seen on the tip of the Tail on the 13th and farther northwest on the Bank on the 17th. This was the last report of ice in the region of the Tail for June, so one can appreciate with what suddenness the relatively large group of bergs in positions south of the Tail disappeared from these waters during this month.

Bergs on the northern part of the Bank, on the contrary, continued to be reported with little abatement during the entire month. There were many reports which referred to the same bergs, this fact being quite apparent to anyone charged with keeping a careful check on the total number of bergs. The tendency of drift of these bergs was quite in accordance with what has been observed in previous years, namely, to ground and drag along the bottom and break up

on the northern slopes of the Grand Bank. Then as the season grew older, the latter part of the month, an increasing number of bergs were reported in positions along the east coast of Newfoundland, and in the deep-water gully which leads around Cape Race. Such a tendency as described is well shown on Figure 18, as is also the comparatively large number of bergs which collected and stranded on the northern part of the Bank. A report from the steamship *Empress of France* on June 30 indicated a decrease in numbers even here.

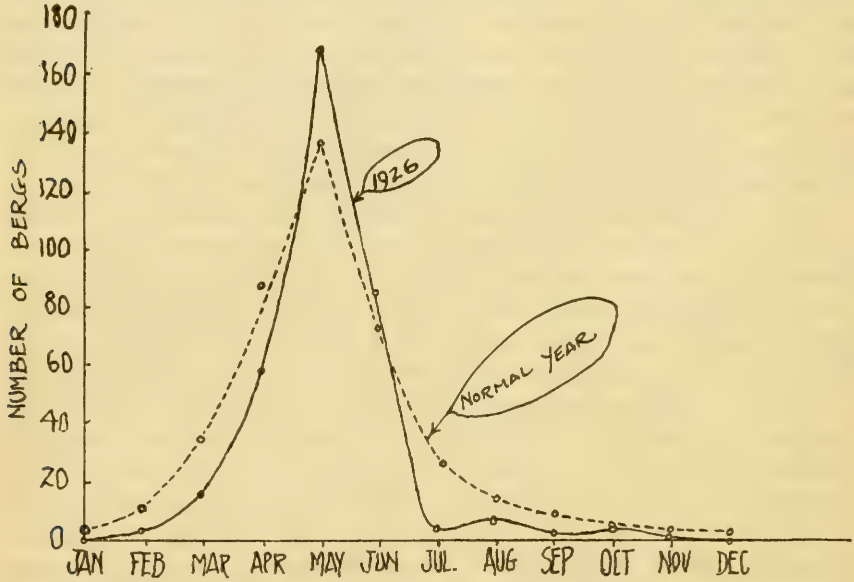

FIG. 20.—Distribution of icebergs south of Newfoundland, 1926. The full black curved line represents the actual distribution, while the dotted line is the normal distribution

The absence of berg reports between parallels 43 and 46 on the eastern side of the Grand Bank was quite noticeable if we but glance at Figure 18. The three or four which were sighted in this locality drifted eastward on the inner edge of the Gulf Stream and did not get south of the Tail. The underlying cause for such a dispersal is contained in a current map especially compiled by the *Tampa* just prior to the discontinuance of the patrol on the 30th instant.

Summarizing, we state that there was a total of 85 bergs south of the forty-eighth parallel, about 10 per cent more than normal, and of this number there were 12 south of the Tail of the Grand Bank, all for the month of June. The most outstanding feature was the rapid decrease in numbers of bergs drifting southward of Newfoundland during June. The waters, after the 17th instant, were entirely free of bergs that could possibly, from currents, and experience

of previous years, drift southward and jeopardize trans-Atlantic navigation.

The distribution of icebergs south of Newfoundland by months during 1926 was:

January	0	April	58	July	4	October	3
February	3	May	168	August	6	November	1
March	15	June	85	September	2	December	0

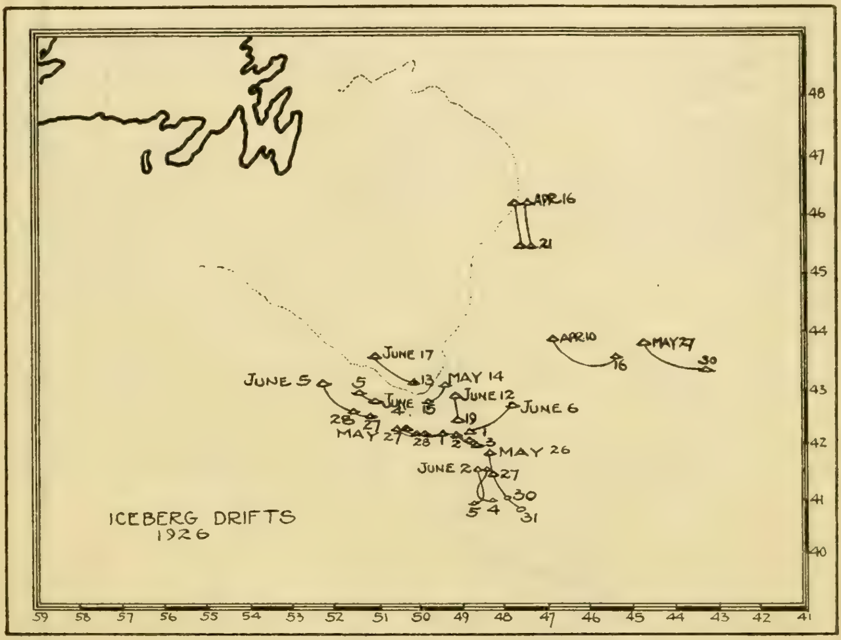

FIG. 21.—Iceberg drifts recorded during the season of 1926

This is shown graphically by a full black line, Figure 20, page 72. The normal distribution is shown as a dotted line.

The bergs that the patrol were able to track in drifts during the ice season are recorded on Figure 21.

A compilation has been made of all the drifts of icebergs around the Grand Bank that the ice patrol has been able to follow, and this chart is shown here.

FIG. 22.—Chart of compiled drifts of icebergs, 1914-1926

SUMMARY OF ICEBERG RECORDS IN THE NORTH-WESTERN NORTH ATLANTIC, 1880-1926

In connection with the ice forecasting work described in the "Weather" section (pp. 31–48) it has been found necessary to collect the very best data from all sources on the amounts of ice from year to year and month to month. For the period 1880 to 1900 advantage was taken of the figures compiled by Mecking and also those of Schott, these investigators having based their comparative estimates of these years on records of the Deutsche Seewarte, the United States Hydrographic Office, the United States Weather Bureau, the United States Signal Service. We made an actual count of the number of icebergs south of Newfoundland by months for the period 1900–1926, and the records consulted in this task were those of the International Ice Patrol, and the United States Hydrographic Office. For the sake of record a table of the actual iceberg count is appended herewith, followed by a table of iceberg anomalies:

NUMBER OF ICEBERGS SOUTH OF NEWFOUNDLAND (48TH PARALLEL) IN WESTERN NORTH ATLANTIC

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1900	10	0	0	5	32	33	6	1	1	1	0	0	89
1901	1	0	0	4	13	29	22	6	5	1	2	5	88
1902	3	0	1	1	13	5	16	1	0	1	0	0	41
1903	0	2	400	166	151	52	23	7	0	0	0	1	802
1904	0	0	12	63	82	89	14	3	2	0	0	0	265
1905	3	2	168	373	109	100	50	9	8	8	0	15	845
1906	14	11	77	49	133	87	18	16	0	0	0	0	405
1907	0	1	11	162	248	138	64	11	0	0	0	3	638
1908	1	0	7	39	82	51	2	2	20	15	3	0	222
1909	0	55	147	134	321	181	121	45	19	1	0	0	1,024
1910	0	0	0	34	10	3	3	0	0	0	0	0	50
1911	0	8	41	112	72	77	21	40	3	0	8	14	396
1912	1	0	34	395	345	159	63	19	0	0	3	0	1,019
1913	2	4	37	109	292	71	14	4	7	0	6	4	550
1914	1	41	32	27	419	71	22	46	52	13	1	6	731
1915	14	72	67	96	97	71	28	17	5	0	1	0	468
1916	0	0	0	0	25	29	0	0	0	0	0	0	54
1917	0	0	13	3	3	9	10	0	0	0	0	0	38
1918	0	0	12	23	26	37	27	34	22	1	14	3	199
1919	3	4	5	25	75	56	26	36	69	2	12	4	317
1920	6	43	20	5	211	86	18	5	18	19	10	4	445
1921	17	5	43	210	198	175	53	24	4	10	1	6	746
1922	0	3	35	71	245	83	21	11	6	27	21	0	523
1923	0	3	28	65	83	42	10	3	2	0	0	0	236
1924	3	0	6	2.	0	0	0	0	0	0	0	0	11
1925	0	3	5	8	58	22	13	0	0	0	0	0	109
1926	0	3	15	58	168	85	4	6	2	3	1	0	345

TABLE OF ICEBERG ANOMALIES

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Normals	3	10	[1] 36	83	130	68	25	13	9	4	3	2	[1] 386
1900	+7	−10	−36	−78	−98	−35	−19	−12	−8	−3	−3	−2	−297
1901	−2	−10	−36	−79	−117	−39	−3	−7	−4	−3	−1	+3	−298
1902	0	−10	−35	−82	−117	−63	−9	−12	−9	−3	−3	−2	−345
1903	−3	−8	+364	+83	+21	−16	−2	−6	−9	−4	−3	−1	+416
1904	−3	−10	−24	−20	−48	+21	−11	−10	−7	−4	−3	−2	−121
1905	0	−8	+132	+290	−21	+32	+25	−4	−1	+4	−3	+13	+459
1906	+11	+1	+41	−34	+3	+19	−7	+3	−9	−4	−3	−2	+19
1907	−3	−9	−25	+79	+118	+70	+39	−2	−9	−4	−3	+1	+252
1908	−2	−10	−29	−44	−48	−17	−23	−11	+11	+11	0	−2	−164
1909	−3	+45	+111	+51	+191	+113	+96	+32	+10	−3	−3	−2	+638
1910	−3	−10	−36	−49	−120	−65	−22	−13	−9	−4	−3	−2	−336
1911	−3	−2	+5	+29	−58	+9	−4	+27	−6	−4	+5	+12	+10
1912	−2	−10	−2	+312	+215	+91	+38	+6	−9	−4	0	−2	+633
1913	−1	−6	+1	+26	+162	+3	−11	−9	−2	−4	+3	+2	+164
1914	−2	+31	−4	−56	+289	+3	−3	+33	+43	+9	−2	+4	+345
1915	+11	+62	+31	+13	−33	+3	+3	+4	−4	−4	−2	−2	+82
1916	−3	−10	−36	−83	−105	−39	−25	−13	−9	−4	−3	−2	−332
1917	−3	−10	−23	−80	−127	−59	−15	−13	−9	−4	−3	−2	−348
1918	−3	−10	−24	−60	−104	−31	+2	+21	+13	−3	+11	+1	−187
1919	0	−6	−31	−58	−55	−12	+1	+23	+60	−2	+9	+2	−69
1920	+3	+33	−16	−78	+81	+18	−7	−8	+9	+15	+7	+2	+59
1921	+14	−5	+7	+127	+68	+107	+28	+11	−5	+6	−2	+4	+360
1922	−3	−7	−1	−12	+115	+15	−4	−2	−3	+23	+18	−2	+137
1923	−3	−7	−8	−18	−47	−26	−15	−10	−7	−4	−3	−2	−150
1924	0	−10	−30	−81	−130	−68	−25	−13	−9	−4	−3	−2	−375
1925	−3	−7	−31	−75	−72	−46	−12	−13	−9	−4	−3	−2	−277
1926	−3	−7	−21	−25	+38	+17	−21	−7	−7	−1	−2	−2	−41

[1] Based on March, 1903, with weight of 150 instead of 400.

The character of the iceberg seasons 1880–1926 is represented by the following table based on a value of 0 to 10:

Year	0	1	2	3	4	5	6	7	8	9
1880	4.7	2.4	6.1	4.7	6.4	7.4	4.0	5.0	4.3	3.5
1890	8.6	3.1	4.0	4.4	6.1	3.0	3.8	6.1	5.1	5.4
1900	3.0	3.0	2.5	7.3	4.1	7.4	4.7	6.4	3.8	8.6
1910	2.8	4.6	8.6	5.7	6.8	5.4	2.8	2.5	3.7	4.2
1920	5.1	6.8	5.9	4.1	2.0	3.3	4.3	....	....	....

This table is represented graphically by Figure 23.

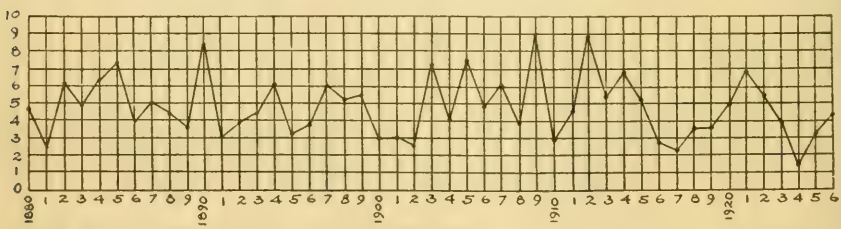

FIG. 23.—The iceberg character of the years 1880–1926, based on a scale 0 to 10. Mean value 4.8

We may now take the iceberg count for the period 1900–1926 and by computing the average of each series of months obtain the normal number of bergs for the western North Atlantic for each one of the 12 months.

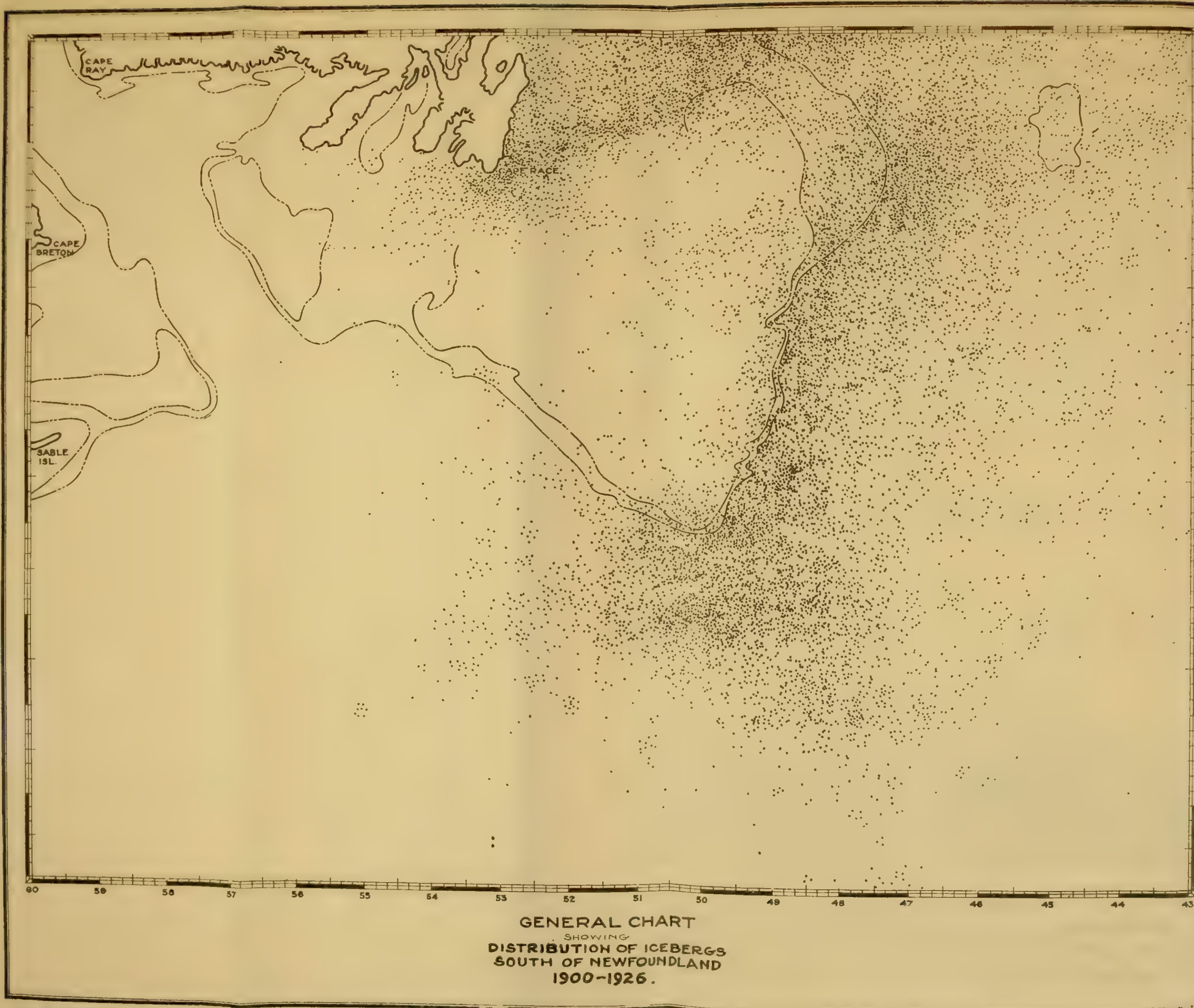

FIG. 25.—Distribution of icebergs south of Newfoundland, 1900–1926, compiled from steamer reports and ice-patrol reports contained in the weekly Hydrographic Bulletins of the United States Hydrographic Office

Normal number of icebergs south of the forty-eighth parallel (menace to the Cape Race tracks)

January	3	April	83	July	25	October	4
February	10	May	130	August	13	November	3
March	36	June	68	September	9	December	2

Normal number of icebergs south of the Grand Bank (menace to the United States to Europe tracks)

January	0	April	9	July	3	October	0
February	1	May	18	August	2	November	0
March	4	June	13	September	1	December	0

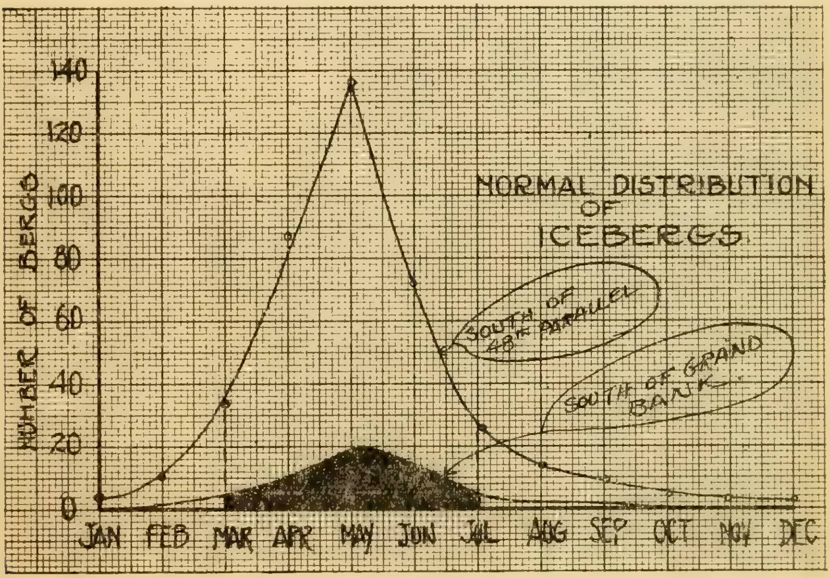

FIG. 24.—The normal monthly distribution of icebergs in the western North Atlantic—(*a*) south of Newfoundland (48th parallel); (*b*) South of the Grand Bank. The black area represents the span of the normal ice season as interpreted by the ice patrol

The monthly distribution throughout a normal year is represented by the two curves on Figure 24. The space between the two dotted vertical lines embraces the normal ice season, March to July. It can be seen from the foregoing that there are really no ice-free months on the Cape Race tracks, while there are only four such months on the United States to Europe tracks.

In the course of the research work which has been carried on by the International Ice Patrol there has been plotted on a chart the position of those icebergs reported by steamships during the period 1900–1926. This material has been taken from the file of United States Hydrographic Office publications, principally the Hydrographic Bulletin.

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δ_t at head of column 9 represents the value, density in situ.
V at head of column 10 represents the value, specific volume in situ.
$V-V_1$ at head of column 11 represents the value, anomaly of specific volume in situ.
E at head of column 12 represents the value, height in dynamic meters.
$E-E_1$ at head of column 13 represents the value, anomaly of dynamic height.

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: $V-V_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: $E-E_1$
		° ′	° ′			°C						
554	Mar. 28	42 55	55 50	4,300	0	1.8	33.06	26.45	0.97423	159	0	0
					25	1.4	33.02	26.45	.97423	170	24.35438	.03973
					50	1.2	33.11	26.53	.97392	150	48.70488	.07838
					125	[b]1.4	[b]33.58	26.84	.97331	123	121.72601	.18009
					250	2.8	34.36	27.45	.97218	66	243.31914	.29915
					450	4.2	34.87	27.67	.97110	48	437.65714	.42367
					750	4.1	34.91	27.73	.96973	44	728.78164	.56215
555	Mar. 29	42 47	53 00	4,040	0	2.2	33.46	26.75	.97394	130	0	0
					25	3.3	33.48	26.66	.97392	139	24.34825	.02360
					50	5.2	33.84	26.75	.97371	129	48.69363	.06713
					125	[b]7.2	[b]34.50	27.02	.97315	107	121.70088	.15576
					250	6.3	34.78	27.35	.97229	77	243.29088	.27089
					450	4.9	34.94	27.65	.97112	50	437.63188	.39839
					750	4.1	34.94	27.74	.96972	21	728.75788	.53839
556	do	43 10	52 31	2,550	0	1.0	33.75	27.06	.97365	99	0	0
					25	0.8	33.72	27.05	.97355	102	24.34050	.02585
					50	0.5	33.74	27.08	.97341	99	48.67745	.05095
					125	2.0	34.22	27.37	.97281	79	121.66075	.11563
					250	4.0	34.74	27.60	.97204	42	243.21288	.19289
					450	3.8	34.81	27.68	.97109	37	437.52588	.29239
					750	4.0	34.93	27.76	.96970	41	728.64438	.42489
557	Apr. 8	43 47	50 24	60	0	0.8	32.78	26.29	.97438	174	0	0
					13	0.5	32.78	26.30	.97431	------	12.92305	------
					26	0.3	32.76	26.30	.97426	------	25.58879	------
					39	0.5	32.78	26.30	.97417	------	38.25365	------
					50	------	------	[c]26.30	.97414	172	48.96941	.34291
					52	0.5	32.78	26.30	.97413	------	50.91769	------
558	Apr. 26	42 56	52 59	3,000	0	0.6	33.37	26.78	.97392	128	0	0
					25	0.6	33.39	26.80	.97399	146	24.34638	.03173
					50	0.6	33.69	27.04	.97344	102	48.68676	.06026
					125	2.2	24.31	27.42	.97276	68	121.66926	.12414
					250	2.5	34.58	27.62	.97201	49	243.21739	.19740
					450	3.3	34.78	27.70	.97106	44	437.52439	.29090
					750	3.5	34.88	27.76	.96969	40	728.65189	.43240
559	do	43 14	52 35	1,963	0	2.4	33.17	26.49	.97419	155	0	0
					25	1.8	33.59	26.88	.97371	118	24.34875	.03410
					50	1.0	33.72	27.03	.97345	103	48.68825	.06175
					125	2.4	34.31	27.40	.97278	70	121.68188	.13676
					250	4.0	34.73	27.58	.97215	63	243.22376	.20377
					450	3.3	34.77	27.68	.97108	46	437.53676	.30327
					750	3.6	34.88	27.77	.96968	39	728.65076	.43127
560	do	43 33	52 10	995	0	1.4	33.14	26.54	.97414	150	0	0
					25	1.5	33.17	26.56	.97402	149	24.35200	.03735
					50	0.4	33.22	26.68	.97378	136	48.69950	.07300
					125	−0.6	33.59	27.01	.97314	106	121.70900	.16388
					250	0.4	33.96	27.26	.97235	83	243.30213	.28214
					450	2.2	34.52	27.59	.97116	54	437.65313	.41964
					750	3.1	34.74	27.68	.96977	48	728.79263	.57214
561	Apr. 28	43 01	51 04	784	0	0.0	33.18	26.66	.97403	139	0	0
					25	[b]0.3	33.18	26.67	.97391	138	24.34925	.03460
					50	[b]1.3	33.28	26.79	.97368	126	48.69413	.06763
					125	0.25	33.75	27.10	.97306	98	121.69688	.15176
					250	2.3	34.35	27.44	.97218	66	243.27438	.25439
					450	2.45	34.61	27.64	.97111	49	437.60338	.36989
					750	3.3	34.78	27.69	.96976	47	728.73388	.51439

[b] Differs from observed, having been corrected for smooth curves of temperature, salinity, and density.
[c] Interpolated.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: $V-V_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: $E-E_1$
		° ′	° ′			°C						
562	Apr. 28	42 41	51 19	2,244	0	3.2	33.47	26.66	.97403	139	0	0
					25	2.8	33.50	26.72	.97386	133	24.34863	.02398
					50	1.3	33.58	26.90	.97357	115	48.69151	.06501
					125	3.6	34.47	27.42	.97276	68	121.74889	.20377
					250	3.9	34.71	27.58	.97205	53	243.29952	.27953
					450	3.85	34.86	27.71	.97105	43	437.60952	.37603
					750	3.5	35.01	27.80	.96965	36	728.71452	.49503
563	do	42 22	51 34	3,322	0	3.0	33.10	26.38	.97430	166	0	0
					25	2.2	33.18	26.51	.97406	143	24.35446	.03981
					50	0.7	33.69	27.02	.97346	94	48.69850	.07200
					125	3.35	34.47	27.44	.97274	66	121.68100	.13588
					250	3.45	34.72	27.63	.97200	48	243.22725	.20726
					450	3.9	34.89	27.72	.97104	42	437.53125	.29776
					750	3.8	34.95	27.78	.96967	38	728.63775	.41826
564	do	42 04	51 48	3,657	0	3.2	33.25	26.48	.97420	156	0	0
					25	0.8	33.73	27.06	.97355	102	24.34688	.03223
					50	1.3	34.07	27.29	.97321	79	48.68138	.05488
					125	2.3	34.45	27.43	.97274	66	121.65451	.10839
					250	4.7	34.93	27.67	.97199	47	243.20014	.18015
					450	4.3	34.95	27.73	.97104	42	437.50314	.26965
					750	3.95	34.96	27.78	.96968	39	728.61114	.39165
565	Apr. 29	41 47	52 02	3,800	0	2.5	33.07	26.42	.97426	152	0	0
					25	5.0	33.69	26.65	.97393	140	24.35338	.03773
					50	4.5	33.90	26.92	.97355	113	48.69588	.06938
					125	7.5	34.63	27.07	.97311	103	121.69563	.15051
					250	7.1	34.91	27.21	.97243	91	243.29188	.27189
					450	[b]6.1	[b]34.92	27.50	.97128	56	437.66288	.42939
					750	4.2	34.94	27.73	.96973	44	728.81438	.59489
566	do	41 06	50 16	3,800	0	16.0	36.17	26.65	.97403	139	0	0
					25	15.7	36.10	26.66	.97391	138	24.34938	.03473
					50	15.0	35.95	26.69	.97378	136	48.69551	.06901
					125	13.2	35.61	26.84	.97333	125	121.81214	.16702
					250	10.9	35.33	27.08	.97258	106	243.33839	.31840
					450	[b]8.5	35.15	27.35	.97145	83	437.74139	.50790
					750	[b]4.6	34.99	27.73	.96975	46	728.95139	.73190
567	do	41 27	50 14	3,860	0	15.4	36.05	26.69	.97400	136	0	0
					25	15.4	36.04	26.69	.97389	136	24.34863	.03398
					50	15.3	36.02	26.70	.97377	135	48.69438	.06788
					125	13.6	35.75	26.86	.97332	124	121.71036	.16524
					250	10.9	35.36	27.10	.97256	104	243.32786	.30787
					450	[b]8.0	35.11	27.38	.97141	79	437.72486	.49137
					750	[b]4.4	[b]34.94	27.72	.96975	46	728.90036	.68087
568	do	41 48	50 13	3,790	0	6.4	33.73	26.52	.97416	152	0	0
					25	6.6	34.18	26.85	.97374	121	24.34875	.03410
					50	11.0	35.23	26.97	.97352	110	48.68950	.06300
					125	9.9	35.03	27.01	.97316	108	121.69375	.14863
					250	6.0	34.44	27.12	.97251	99	243.29813	.27814
					450	4.8	34.78	27.54	.97123	61	437.67213	.43864
					750	[b]3.8	[b]34.90	27.75	.96971	42	728.81313	.59364
569	do	42 08	50 14	3,352	0	3.8	33.16	26.36	.97432	168	0	0
					25	2.7	33.37	26.62	.97396	143	24.35350	.03885
					50	0.9	33.53	26.89	.97358	116	48.69775	.07125
					125	0.7	34.06	27.33	.97283	75	121.68850	.14338
					250	3.5	34.59	27.53	.97211	59	243.24788	.22789
					450	4.0	34.85	27.68	.97109	47	437.56788	.33439
					750	3.6	34.89	27.75	.96971	42	728.68788	.46839
570	do	42 29	50 14	2,560	0	1.2	33.16	26.57	.97412	148	0	0
					25	1.2	33.37	26.74	.97384	131	24.34950	.03485
					50	3.2	33.73	26.87	.97360	118	48.69250	.06600
					125	2.7	34.12	27.22	.97294	86	121.68675	.14163
					250	3.7	34.58	27.51	.97213	61	243.37713	.25714
					450	3.4	34.78	27.69	.97108	46	437.69713	.46464
					750	3.2	[b]34.87	27.77	.96969	40	728.81363	.59914
571	Apr. 30	42 41	49 39	2,194	0	0.4	33.17	26.63	.97406	142	0	0
					25	0.2	33.24	26.70	.97388	135	24.34925	.03460
					50	2.3	33.65	26.89	.97358	116	48.69250	.06600
					125	3.4	34.21	27.23	.97293	85	121.68663	.14151
					250	2.1	34.42	27.52	.97212	60	243.25126	.23127
					450	3.4	34.76	27.67	.97110	48	437.57326	.33977
					750	[b]3.2	[b]34.68	27.76	.96970	41	728.69326	.47377

[b] Differs from observed having been corrected for smooth curves of temperature, salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	Salinity 0/00	δ_t	a_1 = Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C						
572	Apr. 30	42 28	49 22	2,971	0	4.0	33.32	26.47	.97421	157	0	0
					25	3.7	33.72	26.82	.97377	124	24.34975	.03510
					50	2.7	33.76	26.94	.97353	111	48.69100	.06450
					125	3.1	34.13	27.20	.97296	88	121.68288	.13776
					250	3.9	34.64	27.53	.97211	59	243.24976	.22977
					450	4.3	34.88	27.67	.97110	48	437.57076	.33727
					750	[b] 3.5	[b] 34.90	27.77	.96969	40	728.68926	.46977
573	do	42 10	48 49	3,291	0	3.4	33.07	26.32	.97435	171	0	0
					25	3.0	33.30	26.54	.97403	150	24.35475	.04010
					50	1.6	33.54	26.85	.97362	120	48.70038	.07388
					125	4.8	34.23	27.11	.97306	98	121.7088	.15576
					250	3.5	34.38	27.36	.97227	75	243.40901	.38902
					450	3.1	[b] 34.66	27.62	.97113	51	437.74901	.51552
					750	3.8	[b] 34.89	27.75	.96971	42	728.87501	.65552
574	May 1	41 49	48 14	3,657	0	5.0	33.45	26.46	.97422	158	0	0
					25	4.6	33.81	26.80	.97379	126	24.35013	.03548
					50	8.8	34.75	26.97	.97352	110	48.69151	.06501
					125	9.3	34.99	27.08	.97311	103	121.69014	.14502
					250	3.3	34.30	27.33	.97229	77	243.27814	.25815
					450	[b] 3.4	[b] 34.67	27.59	.97116	54	437.62314	.38965
					750	4.3	[b] 34.91	27.73	.96973	44	728.75664	.53715
575	do	41 28	47 44	3,167	0	14.8	35.94	26.74	.97395	131	0	0
					25	14.6	35.92	26.76	.97383	130	24.34725	.03260
					50	14.4	35.89	26.80	.97368	126	48.69113	.06463
					125	13.3	35.72	26.90	.97327	121	121.70176	.15664
					250	10.7	35.32	27.10	.97256	104	243.31614	.29615
					450	7.1	35.05	27.38	.97140	78	437.71214	.47865
					750	4.7	34.95	27.70	.96978	49	728.88914	.66965
576	do	41 07	47 12	3,230	0	16.7	36.17	26.50	.97418	154	0	0
					25	16.3	36.13	26.52	.97405	152	24.35288	.03823
					50	15.9	36.10	26.62	.97385	143	48.69963	.07313
					125	14.1	35.84	26.83	.97334	126	121.71926	.17414
					250	[b] 11.5	[b] 35.48	27.07	.97259	107	243.33989	.31990
					450	[b] 8.1	[b] 35.11	27.36	.97143	81	437.74189	.50840
					750	[b] 5.0	34.99	27.69	.96979	50	728.92489	.70540
577	May 3	42 57	49 46	760	0	0.0	33.14	26.63	.97406	142	0	0
					25	−0.2	33.14	26.64	.97394	141	24.35000	.03535
					50	−0.1	33.14	26.64	.97382	140	48.69700	.07020
					125	−0.1	33.29	26.76	.97338	130	121.71700	.17188
					250	0.4	33.98	27.28	.97234	82	243.32450	.30451
					450	2.6	34.58	27.60	.97115	53	437.67350	.41001
					750	[b] 3.5	[b] 34.79	27.69	.96976	47	728.81000	.59051
578	May 4	43 44	48 58	548	0	0.5	33.23	26.67	.97402	138	0	0
					25	0.4	33.26	26.68	.97390	137	24.34888	.03423
					50	0.2	33.26	26.68	.97388	136	48.69476	.06826
					125	0.6	34.02	27.30	.97287	79	121.69414	.13902
					250	0.9	34.37	27.56	.97207	55	243.25289	.23290
					450	2.45	34.56	27.60	.97115	53	437.77489	.54140
					750	3.25	34.75	27.67	.96977	48	728.91289	.69340
579	May 5	43 43	48 42	2,560	0	2.7	33.50	26.73	.97396	132	0	0
					25	2.7	33.51	26.73	.97385	132	24.34763	.03298
					50	3.0	33.61	26.79	.97368	126	48.69176	.06526
					125	[b] 4.2	[b] 34.35	27.27	.97291	83	121.68889	.14377
					250	5.1	34.89	27.59	.97206	54	243.25577	.23578
					450	4.3	34.86	27.66	.97110	48	437.57177	.33828
					750	3.9	34.89	27.72	.96974	45	728.69777	.47828
580	do	43 40	48 20	3,108	0	3.4	33.52	26.68	.97401	137	0	0
					25	3.0	33.53	26.73	.97385	132	24.34800	.03335
					50	0.3	33.35	26.78	.97369	127	48.69225	.06575
					125	1.15	33.90	27.17	.97300	92	121.69350	.14838
					250	5.35	34.88	27.55	.97210	58	243.26225	.24226
					450	4.7	34.91	27.63	.97113	51	437.58525	.35216
					750	3.8	34.88	27.73	.96973	44	728.71425	.49476
581	do	43 37	48 02	3,657	0	12.2	35.40	26.87	.97383	119	0	0
					25	12.0	35.37	26.88	.97371	118	24.34425	.02960
					50	11.9	35.38	26.92	.97356	114	48.68538	.05888
					125	10.9	35.38	27.10	.97308	100	121.68438	.13926
					250	7.3	[b] 34.91	27.32	.97233	81	243.27251	.25252
					450	4.4	34.80	27.60	.97116	54	437.62151	.38802
					750	4.5	34.94	27.70	.96975	46	728.75801	.53852

[b] Differs from observed having been corrected for smooth curves of temperature, salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	Salinity 0/00	δ_t	a_1 = Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C						
582	May 6	42 55	49 43	729	0	0.8	33.33	26.73	.97396	132	0	0
					25	0.0	33.34	26.79	.97380	127	24.34700	.03235
					50	-0.2	33.39	26.90	.97357	115	48.68913	.06263
					125	0.7	34.02	27.29	.97289	81	121.68138	.13626
					250	2.6	34.46	27.50	.97214	62	243.24576	.22577
					450	2.7	34.58	27.58	.97117	55	437.57676	.34327
					750	3.3	34.76	27.68	.96976	47	728.61626	.39677
583	May 7	43 50	50 20	58	0	2.4	32.69	26.10				
					12	2.1	32.71	26.14				
					24	1.4	32.77	[b] 26.20				
					36	1.4	32.74	26.22				
					48	1.3	32.82	26.29				
584	May 14	42 53	49 42	850	0	0.8	35.16	26.61	.97408	114	0	0
					25	-0.4	33.22	26.72	.97386	133	24.34925	.03460
					50	-1.0	34.46	[b] 26.80	.97367	125	48.69338	.06688
					125	0.5	33.68	27.03	.97312	104	121.69801	.15289
					250	0.65	34.02	27.30	.97232	80	243.28801	.26802
					450	2.5	34.57	27.61	.97114	52	437.63401	.40052
					750	3.1	34.81	27.72	.96972	43	728.76301	.54352
585	May 18	43 08	51 34	914	0	1.9	32.98	26.38	.97430	166	0	0
					25	-0.2	33.17	26.66	.97392	139	24.35275	.03810
					50	-0.9	33.34	26.82	.97365	123	48.69738	.07088
					125	1.0	34.16	27.39	.97278	70	121.68851	.14339
					250	[b] 2.0	34.54	27.62	.97201	49	243.23664	.21665
					450	2.5	[b] 34.75	27.74	.97101	39	437.53664	.30315
					750	3.2	34.85	27.78	.96966	37	728.48714	.26765
586	do	42 58	51 50	1,280	0	3.8	33.19	26.39	.97429	165	0	0
					25	3.5	33.21	26.43	.97414	161	24.35528	.04073
					50	2.0	33.53	26.82	.97365	123	48.70276	.07626
					125	3.5	34.27	27.27	.97290	82	121.69839	.15327
					250	3.4	34.58	27.53	.97211	59	243.26152	.24153
					450	3.7	34.84	27.70	.97107	45	437.57952	.34603
					750	3.4	34.90	27.78	.96966	37	728.67402	.45453
587	May 19	42 49	52 05	2,560	0	5.2	33.03	26.11	.97455	191	0	0
					25	4.9	32.99	26.12	.97443	190	24.36225	.04760
					50	3.3	33.21	26.46	.97399	157	48.71750	.09100
					125	2.0	33.91	27.12	.97305	97	121.73150	.18638
					250	3.8	34.51	27.45	.97218	66	243.30838	.28839
					450	3.7	34.73	27.62	.97104	52	437.64038	.40689
					750	4.1	34.92	27.73	.96973	44	728.78088	.56139
588	do	42 30	52 00	2,925	0	5.8	33.14	26.13	.97452	188	0	0
					25	3.0	33.24	26.50	.97407	144	24.35738	.04273
					50	2.6	33.51	26.75	.97371	129	48.70463	.07813
					125	2.8	34.34	27.39	.97279	71	121.69763	.15251
					250	[b] 3.8	34.82	27.66	.97199	47	243.35888	.33889
					450	4.1	34.91	27.72	.97105	43	437.66288	.42939
					750	4.2	35.01	27.78	.96968	39	728.77238	.55289
589	do	42 13	51 43	3,500	0	5.8	33.09	26.08	.97458	194	0	0
					25	3.0	33.35	26.58	.97400	147	24.35725	.04250
					50	1.2	33.47	26.82	.97365	123	48.70288	.07638
					125	1.3	33.98	27.22	.97295	87	121.70038	.25526
					250	2.8	34.50	27.52	.97211	59	243.26663	.24664
					450	3.9	34.75	27.62	.97114	52	437.59162	.35813
					750	4.1	34.94	27.75	.96971	42	728.69913	.47964
590	do	42 12	51 11	2,743	0	12.0	34.71	26.38	.97430	166	0	0
					25	12.5	34.81	26.37	.97419	166	24.35613	.04148
					50	14.0	35.78	26.80	.97368	126	48.70451	.07801
					125	[b] 10.9	35.44	27.15	.97302	94	121.70614	.16102
					250	[b] 6.4	34.84	27.39	.97227	75	243.28739	.26740
					450	[b] 4.4	34.85	27.64	.97115	53	437.62939	.39590
					750	[b] 4.1	34.94	27.75	.96971	42	728.75839	.53890
591	do	42 33	51 17	2,377	0	6.2	33.38	26.27	.97440	176	0	0
					25	7.9	34.19	26.67	.97391	138	24.35388	.03923
					50	9.3	34.82	26.95	.97353	111	48.69688	.07038
					125	10.0	35.15	27.18	.97300	92	121.69176	.14664
					250	6.7	34.90	27.40	.97225	73	243.26989	.24990
					450	4.6	34.89	27.65	.97112	50	437.60689	.37340
					750	3.9	34.92	27.75	.96971	42	728.73179	.51190

[b] Differs from observed having been corrected for smooth curves of temperature, salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude °	Latitude ′	Longitude °	Longitude ′	a depth of water	a_1 depth	a = Meters: Temperature °C	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: $V-V_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: $E-E_1$
592	May 19	42	48	51	28	1,645	0	5.3	33.31	26.32	.97435	171	0	0
							25	4.9	33.32	26.37	.97420	157	24.35688	.04223
							50	4.8	34.04	26.95	.97352	110	48.70338	.07688
							125	4.6	34.35	27.23	.97294	86	121.69563	.15051
							250	4.4	[b] 34.50	27.37	.97226	74	243.02063	.00064
							450	4.1	34.67	27.53	.97123	61	437.36963	.13614
							750	3.8	34.89	27.74	.96972	43	728.51213	.29264
593	May 20	42	55	51	07	1,463	0	1.6	32.93	26.36	.97432	168	0	0
							25	0.1	32.94	26.46	.97411	158	24.35538	.04073
							50	−0.8	33.21	26.71	.97375	133	48.70363	.07713
							125	0.1	33.71	27.08	.97308	100	121.70976	.16464
							250	1.5	34.15	27.35	.97227	75	243.29414	.27415
							450	[b] 2.6	34.53	27.56	.97119	57	437.64016	.40667
							750	3.4	34.84	27.74	.96971	42	728.77514	.55565
594	do	42	45	50	35	1,737	0	2.0	33.08	26.45	.97423	159	0	0
							25	1.4	33.11	26.52	.97405	152	24.35350	.03885
							50	−0.9	33.35	26.82	.97365	123	48.69975	.07325
							125	−0.8	33.64	27.06	.97310	102	121.70288	.15776
							250	2.3	34.11	27.32	.97234	82	243.29288	.27289
							450	2.9	34.57	27.57	.97119	57	437.64588	.41239
							750	3.3	34.84	27.74	.96970	41	728.77938	.55989
595	do	42	23	50	33	2,560	0	2.0	32.92	26.33	.97434	170	0	0
							25	1.8	32.98	26.41	.97416	153	24.35624	.04159
							50	0.4	33.31	26.74	.97372	130	48.69974	.07324
							125	1.8	34.39	27.53	.97266	58	121.68900	.14388
							250	3.4	34.73	27.65	.97198	46	243.22900	.21901
							450	3.6	34.82	27.72	.97104	42	437.53100	.29751
							750	3.6	34.90	27.77	.96968	39	728.63900	.41951
596	do	42	05	50	21	3,340	0	4.6	33.02	26.17	.97450	186	0	0
							25	0.6	33.16	26.60	.97398	145	24.35600	.04135
							50	0.7	33.49	26.87	.97360	118	48.70074	.07424
							125	3.4	34.36	27.34	.97284	76	121.69225	.14713
							250	4.6	34.74	27.53	.97212	60	243.26475	.24476
							450	4.8	34.93	27.66	.97112	50	437.58875	.35526
							750	4.5	35.00	27.75	.96970	41	728.71175	.49226
597	June 2	41	24	48	25	3,160	0	16.7	36.09	26.44	.97424	160	0	0
							25	16.4	36.10	26.52	.97405	152	24.35288	.03823
							50	15.9	36.04	26.59	.97388	146	48.70201	.07551
							125	13.7	35.76	26.85	.97332	124	121.72201	.17689
							250	11.1	35.27	26.99	.97266	114	243.34576	.32577
							450	8.1	34.95	27.24	.97154	92	437.76576	.53227
							750	4.6	34.90	27.65	.96981	52	728.96826	.74877
598	do	41	12	48	39	3,150	0	16.7	36.10	26.45	.97423	159	0	0
							25	16.2	36.08	26.55	.97402	149	24.35300	.03835
							50	15.4	36.04	26.59	.97388	146	48.70175	.07525
							125	13.9	35.82	26.86	.97331	123	121.72138	.17628
							250	11.5	35.38	27.00	.97265	113	243.34388	.32389
							450	7.9	34.89	27.26	.97153	91	437.76188	.52839
							750	4.5	34.87	27.65	.96981	52	728.96288	.74339
599	June 3	41	25	48	45	3,790	0	16.4	36.17	26.57	.97412	148	0	0
							25	16.6	36.13	26.58	.97400	147	24.35150	.03685
							50	15.9	36.08	26.61	.97386	144	48.69975	.07325
							125	13.8	35.80	26.85	.97332	124	121.71900	.17388
							250	12.0	35.48	26.98	.97267	115	243.33713	.31714
							450	8.2	35.04	27.30	.97149	77	437.75313	.51964
							750	5.3	35.00	27.66	.96981	52	728.94813	.72864
600	June 16	42	42	50	18	1,828	0	8.0	32.54	25.35	.97527	263	0	0
							25	7.5	33.65	26.44	.97413	160	24.36750	.05285
							50	5.1	33.48	26.48	.97382	140	48.71688	.09038
							125	1.8	33.82	27.08	.97309	101	121.72602	.18090
							250	2.7	34.03	27.38	.97224	72	243.30917	.28918
							450	5.2	34.68	27.42	.97122	60	437.65517	.42168
							750	4.6	34.95	27.70	.96977	48	728.80367	.58418
601	do	42	32	50	18	2,194	0	9.8	33.88	26.13	.97453	189	0	0
							25	10.2	33.97	26.13	.97442	189	24.36188	.04723
							50	10.6	35.18	26.30	.97415	173	48.71901	.09251
							125	10.75	35.19	27.00	.97317	109	121.74351	.19839
							250	7.8	34.85	27.21	.97239	87	243.34101	.32102
							450	4.9	34.69	27.46	.97131	69	437.71101	.47752
							750	4.3	34.98	27.75	.96971	42	728.86401	.64452

[b] Differs from observed, having been corrected for smooth curves of temperature salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters Temperature	 Salinity 0/00	 δ_t	a_1 = Pressure in decibars V	 V−V$_1$	 E	 E−E$_1$
		° ′	° ′			°C						
602	June 16	42 22	50 17	2,590	0	10.2	33.26	25.57	.97512	248	0	0
					25	10.5	33.48	25.70	.97483	230	24.37438	.05973
					50	10.8	33.91	25.98	.97446	204	48.74051	.11401
					125	5.3	34.43	27.30	.97297	89	121.76915	.22403
					250	3.5	34.68	27.60	.97211	59	243.33665	.31666
					450	4.1	34.83	27.66	.97111	49	437.65765	.42416
					750	4.5	34.94	27.70	.96975	46	728.78665	.56716
603	do	42 11.5	50 18	2,800	0	9.0	32.94	25.52	.97511	247	0	0
					25	7.9	32.97	25.70	.97483	230	24.37425	.05960
					50	1.5	33.18	26.57	.97389	147	48.73325	.10665
					125	0.8	33.91	27.25	.97291	83	121.73825	.19313
					250	4.4	34.59	27.45	.97208	56	243.30013	.28014
					450	[b]4.5	[b]34.85	27.69	.97108	46	437.61613	.37264
					750	4.1	34.94	27.77	.96970	41	728.73313	.51364
604	June 19	43 50	50 25	62	0	7.7	32.78	25.60	.97504	240	----------	-------
					13	6.9	32.81	25.73	--------	------	----------	-------
					26	6.3	32.81	25.80	--------	------	----------	-------
					39	1.5	33.07	26.48	--------	------	----------	-------
					52	1.4	33.08	26.50	--------	------	----------	-------
605	June 25	42 06	52 50	4,700	0	18.9	36.02	25.85	.97480	216	0	0
					25	18.4	36.03	25.98	.97457	204	24.36712	.05247
					50	17.4	36.04	26.23	.97422	180	48.72700	.10050
					125	17.5	35.80	26.71	.97345	137	121.76380	.21868
					250	[b]11.0	35.50	27.18	.97248	96	243.38190	.36191
					450	[b]7.5	35.20	27.53	.97126	64	437.75590	.52241
					750	4.6	34.84	27.61	.96985	56	728.92240	.70291
606	do	42 25	52 59	4,571	0	17.4	35.68	25.95	.97470	206	0	0
					25	16.6	35.65	26.12	.97443	190	24.36412	.04947
					50	14.2	35.71	26.71	.97376	134	48.71650	.09000
					125	11.8	35.45	27.00	.97318	110	121.72675	.18163
					250	[b]8.9	[b]35.10	27.23	.97242	90	243.32675	.30676
					450	6.0	34.83	27.44	.97133	71	437.70175	.46826
					750	4.4	34.93	27.71	.96976	47	728.86525	.64576
607	June 26	42 43	53 07	4,023	0	11.7	32.98	25.10	.97551	287	0	0
					25	10.5	32.98	25.31	.97520	267	24.38388	.06923
					50	9.6	33.16	25.60	.97482	240	48.75913	.13263
					125	8.0	34.92	27.23	.97295	87	121.80051	.25539
					250	5.8	34.70	27.36	.97228	76	243.37739	.35740
					450	4.0	34.73	27.59	.97117	55	437.72239	.48890
					750	4.0	34.92	27.74	.96972	43	728.85589	.63640
608	do	43 06	52 39	2,560	0	9.1	33.17	25.69	.97495	231	0	0
					25	[b]7.5	33.14	25.90	.97464	211	24.36988	.05523
					50	2.1	33.59	26.86	.97361	119	48.72300	.09650
					125	2.4	34.16	27.29	.97289	81	121.71675	.17163
					250	3.2	34.54	27.52	.97211	59	243.27925	.25926
					450	3.9	34.77	27.63	.97113	51	437.60325	.36976
					750	4.4	34.91	27.69	.96978	49	728.73975	.52026
609	do	43 29	52 09	1,033	0	11.7	34.12	25.98	.97468	204	0	0
					25	9.4	34.09	[c]26.36	.97421	168	24.36112	.04647
					50	4.1	34.07	27.06	.97343	101	48.70662	.08012
					125	[b]3.5	34.33	27.32	.97286	78	121.69250	.14738
					250	3.8	[b]34.54	27.46	.97218	66	243.25750	.23751
					450	4.1	[b]34.65	27.52	.97124	62	437.59950	.36601
					750	3.6	34.75	27.64	.96980	51	728.75550	.53601
610	do	42 56	51 14	1,510	0	12.5	33.81	25.59	.97505	241	0	0
					25	[b]12.3	35.15	26.67	.97391	138	24.36200	.04735
					50	12.0	35.44	26.95	.97354	112	48.70512	.07862
					125	10.4	35.28	27.12	.97306	98	121.70262	.15750
					250	5.9	34.64	27.30	.97234	82	243.29012	.27013
					450	3.6	34.68	27.59	.97117	55	437.64112	.40763
					750	4.4	34.90	27.68	.96979	50	728.78512	.56563
611	do	42 39	51 27	2,304	0	11.4	33.22	25.34	.97528	264	0	0
					25	7.6	33.20	25.94	.97460	207	24.37350	.05885
					50	5.4	34.19	27.01	.97347	105	48.72438	.09788
					125	[b]4.0	34.73	27.31	.97287	79	121.71213	.16701
					250	3.4	34.63	27.57	.97206	54	243.27025	.25026
					450	4.0	34.87	27.70	.97107	45	437.58325	.34976
					750	4.0	34.91	27.72	.96974	45	728.70475	.48526

[b] Differs from observed, having been corrected for smooth curves of temperature, salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: $V-V_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: $E-E_1$
		° ′	° ′			°C						
612	June 26	42 20	51 42	2,956	0	11.6	33.16	25.25	.97537	273	0	0
					25	8.9	33.19	25.74	.97479	226	24.37700	.06235
					50	1.7	33.64	26.93	.97354	112	48.73112	.10462
					125	2.0	34.22	27.37	.97281	73	121.71924	.17412
					250	3.4	34.69	27.61	.97202	50	243.27112	.25113
					450	4.0	34.89	27.72	.97105	43	437.57812	.34463
					750	4.0	34.91	27.73	.96973	44	728.69512	.47563
613	do	41 59	51 52	3,660	0	17.0	35.46	25.88	.97477	213	0	0
					25	17.1	35.71	26.05	.97450	197	24.36588	.05123
					50	15.0	35.75	26.58	.97389	147	48.72076	.09426
					125	12.2	[b]35.56	27.01	.97317	109	121.73551	.19039
					250	[b]9.0	35.34	27.41	.97225	73	243.32426	.30427
					450	[b]6.0	35.14	27.685	.97110	48	437.65926	.42577
					750	4.4	35.00	27.76	.96971	42	728.78076	.56127
614	June 27	41 36	52 02	3,860	0	17.4	35.79	26.04	.97462	198	0	0
					25	17.0	35.72	26.08	.97447	194	24.36362	.04897
					50	16.1	35.68	26.27	.97418	176	48.72174	.09524
					125	14.8	35.96	26.77	.97340	132	121.75599	.21087
					250	[b]11.6	35.47	27.05	.97260	108	243.38099	.36100
					450	8.0	34.98	27.28	.97151	89	437.79199	.55850
					750	4.5	34.89	27.67	.96980	51	728.98849	.76900
615	do	41 09	50 20	3,765	0	15.8	35.07	25.86	.97479	215	0	0
					25	[b]15.8	35.21	25.97	.97458	205	24.36712	.05247
					50	15.8	35.63	26.30	.97415	173	48.72624	.09974
					125	13.8	35.76	26.83	.97334	126	121.75712	.21200
					250	11.9	35.46	26.99	.97266	114	243.38212	.36213
					450	8.2	35.07	27.32	.97147	85	437.79512	.56163
					750	[b]4.5	34.99	27.74	.96973	44	728.97512	.75563
616	do	41 32	50 19	3,700	0	18.7	35.79	25.72	.97492	228	0	0
					25	18.4	35.97	25.93	.97461	208	24.36912	.05447
					50	15.5	35.55	26.30	.97415	173	48.72862	.10212
					125	13.2	35.64	26.87	.97330	122	121.75800	.21288
					250	11.0	35.28	27.01	.97264	112	243.37925	.35926
					450	5.3	34.69	27.41	.97135	73	437.77825	.54476
					750	3.3	34.71	27.65	.96980	51	728.95075	.73126
617	do	41 56	50 19	3,430	0	13.6	33.32	25.00	.97561	297	0	0
					25	10.8	33.68	25.80	.97474	221	24.37938	.06473
					50	2.4	33.19	26.51	.97394	152	48.73788	.11138
					125	9.2	35.00	27.10	.97308	100	121.75113	.20601
					250	6.0	34.77	27.39	.97225	73	243.33425	.31426
					450	3.8	34.75	27.63	.97113	51	437.67225	.43876
					750	4.4	35.00	27.76	.96971	42	728.79825	.57876
618	do	42 21	50 18	2,864	0	11.8	33.56	25.55	.97508	244	0	0
					25	9.4	33.67	26.03	.97452	199	24.37000	.05535
					50	4.0	33.92	26.95	.97353	111	48.72062	.09412
					125	4.2	34.41	27.32	.97268	78	121.71024	.16512
					250	4.3	34.74	27.56	.97208	56	243.26899	.24900
					450	4.6	34.95	27.70	.97108	46	437.58499	.35150
					750	4.0	34.93	27.75	.96971	42	728.70349	.48400
619	do	42 46	50 16	1,798	0	12.0	33.96	25.80	.97485	221	0	0
					25	9.8	34.67	26.75	.97383	130	24.35850	.04385
					50	11.5	35.31	26.95	.97353	111	48.70050	.07400
					125	10.1	35.10	27.01	.97316	108	121.70136	.15624
					250	[b]7.0	[b]34.78	27.26	.97239	87	243.29824	.27825
					450	4.3	34.81	27.62	.97114	52	437.65124	.41775
					750	3.4	34.89	27.78	.96967	38	728.77274	.55325
620	June 28	42 51	49 47.5	777	0	9.7	33.38	25.75	.97489	225	0	0
					25	8.5	33.66	26.16	.97440	187	24.36613	.05148
					50	2.4	33.54	26.79	.97368	126	48.71713	.09063
					125	1.9	33.94	27.15	.97302	94	121.71838	.17326
					250	3.4	34.37	27.36	.97226	74	243.42338	.40339
					450	4.4	34.86	27.65	.97111	49	437.76038	.52689
					750	3.8	[b]34.90	27.75	.96971	42	728.88338	.66389
621	do	42 30	49 20	2,560	0	5.7	32.95	25.99	.97467	203	0	0
					25	6.6	33.94	26.66	.97392	139	24.35738	.04273
					50	11.2	35.29	26.99	.97350	108	48.70013	.07363
					125	7.9	34.82	27.17	.97301	93	121.69426	.14914
					250	5.3	34.52	27.28	.97236	84	243.27989	.25990
					450	[b]3.9	34.64	27.53	.97123	61	437.63889	.40540
					750	4.2	34.82	27.65	.96980	51	728.79339	.57390

[b] Differs from observed, having been corrected for smooth curves of temperature, salinity, and density.

Oceanographic station data and dynamic calculations, 1926—Continued

Station	Date	Latitude	Longitude	*a* depth of water	a_1 depth	*a* = Meters: Temperature	Salinity 0/00	δ_t	a_1 = Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C						
622	June 28	43 45	49 00	1,060	0	5.6	32.87	25.95	.97470	206	0	0
					25	4.6	32.88	26.06	.97449	196	24.36488	.05023
					50	1.1	33.13	26.55	.97391	149	48.71988	.09338
					125	0.6	33.73	27.08	.97308	100	121.73200	.18688
					250	1.7	34.28	27.44	.97218	66	243.31075	.29076
					450	3.0	34.72	27.68	.97108	46	437.63675	.40326
					750	[b] 3.7	34.87	27.74	.96971	42	728.75525	.53576
623	do	43 45	48 33	2,590	0	9.0	32.92	25.50	.97513	249	0	0
					25	7.1	33.03	25.87	.97467	214	24.37250	.05785
					50	1.7	33.85	27.10	.97339	97	48.72325	.09675
					125	2.4	34.48	27.52	.97267	59	121.70050	.15538
					250	[b] 4.5	34.90	27.67	.97198	46	243.24112	.22113
					450	4.0	34.92	27.75	.97102	40	437.54112	.30763
					750	3.7	34.92	27.78	.96967	38	728.64462	.42513
624	do	43 45	48 04	3,125	0	8.2	32.98	25.68	.97496	232	0	0
					25	4.9	33.36	26.41	.97416	163	24.36400	.04935
					50	2.3	34.06	27.22	.97327	85	48.70688	.08038
					125	3.8	34.59	27.50	.97269	61	121.68038	.13526
					250	4.2	34.86	27.67	.97198	46	243.22226	.20227
					450	4.3	34.98	27.76	.97101	39	437.52126	.28777
					750	3.8	34.96	27.80	.96965	36	728.62026	.40077
625	do	43 45	47 40	3,590	0	13.8	33.87	25.38	.97525	261	0	0
					25	13.7	34.17	25.63	.97490	237	24.37688	.06223
					50	13.3	34.47	25.94	.97449	207	48.74426	.11776
					125	9.4	35.00	27.07	.97311	103	121.77926	.23414
					250	5.4	34.62	27.35	.97229	77	243.36676	.34677
					450	4.4	34.84	27.64	.97113	51	437.70876	.47527
					750	4.0	34.94	27.76	.96970	41	728.83326	.61377
626	June 29	42 10	48 54	3,200	0	11.4	34.40	26.25	.97442	178	0	0
					25	11.4	34.49	26.33	.97423	170	24.35813	.04348
					50	10.7	35.22	27.02	.97347	105	48.70438	.07788
					125	8.1	34.86	27.17	.97301	93	121.69738	.15226
					250	4.8	34.67	27.45	.97219	67	243.27238	.25239
					450	4.8	34.92	27.65	.97112	50	437.60338	.36989
					750	3.7	34.85	27.72	.96974	45	728.73088	.51139
627	do	41 50	48 25	3,660	0	11.1	33.28	25.43	.97520	256	0	0
					25	7.7	33.11	25.85	.97469	216	24.37363	.05898
					50	5.5	33.84	26.72	.97375	133	48.72913	.01263
					125	4.8	34.56	27.36	.97283	75	121.72588	.18076
					250	3.9	34.71	27.59	.97205	53	243.28088	.26087
					450	3.9	34.85	27.70	.97107	45	437.59288	.35939
					750	3.9	34.92	27.75	.96971	42	728.70988	.49039
628	do	41 30	47 55	3,175	0	15.4	34.17	25.26	.97536	272	0	0
					25	14.9	34.77	25.83	.97471	218	24.37588	.06123
					50	9.0	34.50	26.75	.97372	130	48.73126	.10476
					125	10.9	35.31	27.05	.97312	104	121.73776	.19264
					250	6.8	34.83	27.33	.97232	80	243.32776	.30777
					450	[b] 4.8	[b] 34.75	27.57	.97120	58	437.67976	.44627
					750	4.4	34.97	27.73	.96974	45	728.82076	.60127
629	do	41 04	47 17	3,245	0	16.6	35.28	25.84	.97481	217	0	0
					25	16.3	35.54	26.11	.97444	191	24.36563	.05098
					50	15.9	36.09	26.62	.97385	143	48.71926	.09276
					125	14.6	35.95	26.81	.97336	128	121.73971	.19459
					250	11.6	35.36	26.96	.97271	119	243.36911	.34912
					450	7.0	35.03	27.46	.97133	71	437.77311	.53962
					750	4.9	34.96	27.67	.96981	52	728.94411	.72462
630	do	40 39	47 08	3,840	0	14.5	33.96	25.30	.97532	268	0	0
					25	15.1	34.92	25.91	.97463	210	24.37438	.05973
					50	14.0	35.62	26.68	.97379	137	48.72963	.10313
					125	13.3	35.70	26.89	.97328	120	121.74475	.19963
					250	11.2	35.37	27.05	.97260	108	243.36225	.34226
					450	8.2	35.15	27.38	.97141	79	437.76325	.52976
					750	5.2	35.04	27.70	.96978	49	728.94175	.72226

[b] Differs from observed, having been corrected for smooth curves of temperature, salinity, and density.

OCEANOGRAPHY

Edward H. Smith

It ought to be emphasized that the London convention which gave genesis to the idea of an ice patrol also laid particular stress upon the importance of collecting scientific data. It was believed that the patrol could give the most efficient economic service to shipping only when scientific methods were employed to support the practical work. Oceanographical investigations of the waters of the ice regions have, during the past 13 years of the service, gradually come to be recognized as contributing a clear and accurate insight into the behavior of floating ice. Such information is not only important for the patrol, but it likewise means greater safety for lives and ships on the North Atlantic. It is obvious that observations restricted solely to the surface do not furnish a true and complete picture of the circulation which is in process, and it is only by including the subsurface that we can hope to obtain a correct view of the interaction between the water masses as a whole.

The oceanographic information of which the patrol makes a complete analysis in arriving at conclusions regarding the behavior of ice, consists of the following:

(*a*) Vertical distribution of salinity, temperature, and density.

(*b*) Horizontal distribution of salinity, temperature, and density.

(*c*) Horizontal distribution of potential (current maps).

Ice scouting is the primary work of the patrol, and this means limiting the number of stations to the minimum and confining the observations to depths no greater than are essential for obtaining the true picture of the circulation. It is also necessary to remember that the more nearly simultaneous the observations can be, the more accurate picture is for the area covered. An ideal program, of course, includes a maximum number of stations distributed netlike over the area investigated and along lines running at right angles to the currents. Therefore, before commencing the observational work all available data as to the hydrographical nature of the ice regions should be carefully studied. This matter received the attention of the Interdepartmental Board on Ice Patrol as early as 1921, when a tentative program was formulated, which has been carried out more or less intensively ever since. The program was revised slightly in 1926 and is described here in some detail, because observations ought to be patterned along the same general lines for several years to come. A standardized program permits ready comparisons between a series of years.

GENERAL PROGRAM OF WORK

The oceanographic plan is based on five lines of stations which run more or less at right angles to the currents and to the general trend of the Grand Bank slopes along the following radials:

Line A: Length 60 miles, 3 stations.
Line B: Length 88 miles, 5 stations.
Line C: Length 100 miles, 5 stations.
Line D: Length 180 miles, 7 stations.
Line E: Length 60 miles, 4 stations.

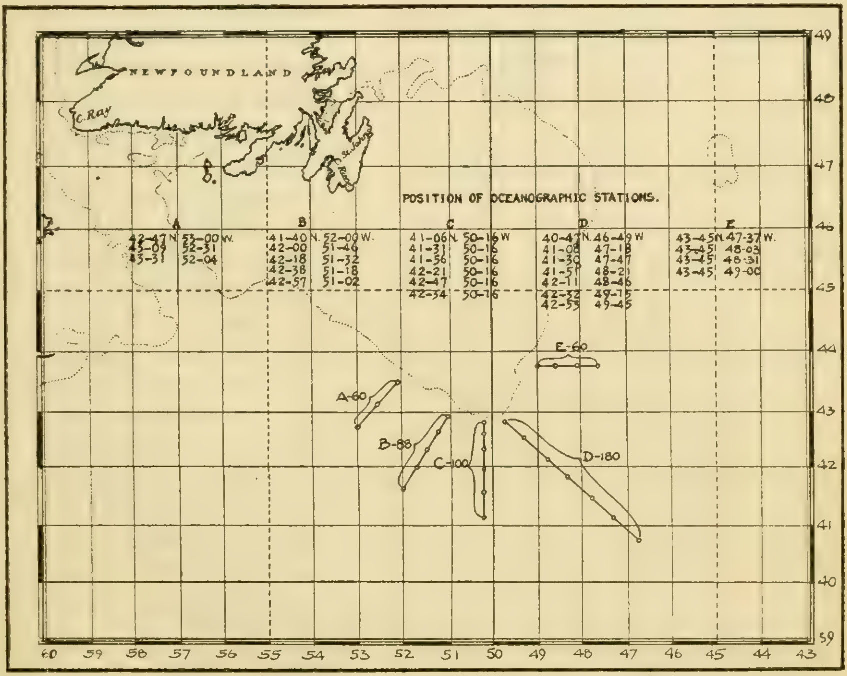

FIG. 26.—The selected position of stations upon which are based the oceanographic surveys conducted by the ice patrol

This distribution of stations permits a vertical examination of the water mass to be extended offshore from five different points along the slope of the Grand Bank, and it also allows us to determine the important physical variations taking place in the ice-infested waters. The distance between stations is set at 20 to 30 miles in order that all the principal features will be detected, and the stations are extended offshore from the Newfoundland shelf for a distance of 60 to 180 miles. The innermost stations are placed as far in on the continental slope as possible, and yet readings secured from the standard maximum depth of observation, 750 meters, without the weights touching bottom. It is important to take temperature and salinity

observations from a sufficient number of levels of depth in order that the change in physical character of the water may be followed in detail. It is equally important that observations be extended downward to abyssal regions where uniformity of conditions tend to prevail. The greatest changes per unit increase in depth in an ocean are generally in the surface layers, and the deeper we penetrate the more homogeneous becomes the mass. A characteristic graph of the density which is based on the two fundamentals, salinity and temperature, is shown in Figure 27. The upper 25 meters is generally kept more or less homogeneous by the mixing effect of the waves, a feature illustrated by the steepness of the density curve. The water column between 25 and 50 meters increases in density very rapidly, i. e., the water is very stable, and this is shown by the horizontality of the curve at A. We find a secondary unevenness in the curve between the 125 and 200 meters depth, B, which is often observed and attributed to the limit of depth of the seasonal effect. Below this point the curve gradually and constantly approaches a straight line as homogeneous abyssal water is entered. In accordance with this normal stratification, the ice patrol has adopted a minimum number of standard depths at which the observations for salinity and temperature are always taken, viz., 0, 25, 50, 125, 250, 450, and 750 meters. It has been found, however, that considerable circulation takes place even below 750 meters, if we proceed as far 120 miles offshore from the continental edge. Therefore it would seem desirable in future years to extend the observations at least to 1,200 meters.

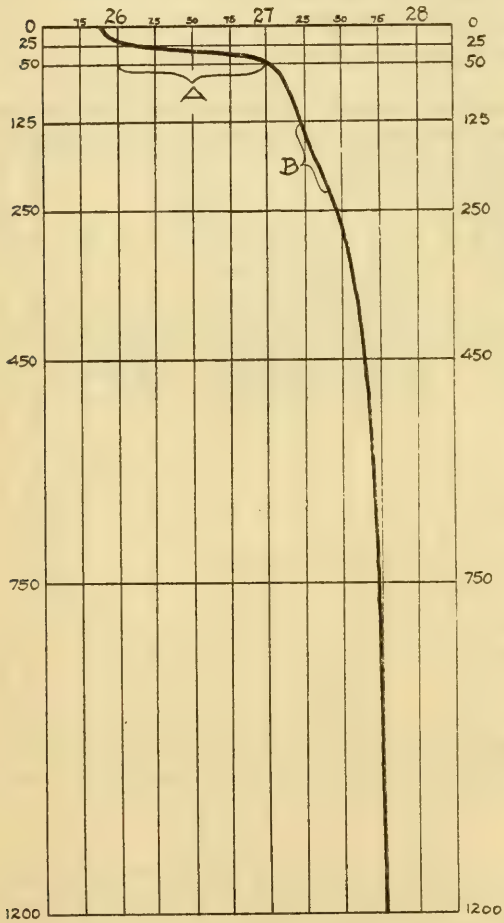

FIG. 27.—An example of the distribution of density with ocean depth

HOW TO AVOID ERRORS IN OBSERVATIONS

It is very easy for one not thoroughly schooled in the art of collecting observations of the temperature and salinity of a water column to make all sorts of errors. Usually the mistake is not detected until some later date when, alas, it is too late to repeat observations and rectify the error. It behooves observers to exercise the greatest care in order that the degree of accuracy be raised as high as possible, and the reputation of the records correspondingly enhanced. The following hints may be found useful by future investigators:

(1) The water bottles should be in the finest working condition, and should be gone over and oiled frequently.

(2) Guard carefully against a tendency for the bottle to close prematurely.

(3) Each bottle should be equipped with two thermometers.

(4) Thermometers should be functioning properly and kept under close observation.

(5) If thermometers in the same bottle do not check, they should be examined.

(6) The mercury column should be continuous from the bulb end when the bottles are lowered over the side.

(7) The meter wheel should be checked occasionally for accuracy of measurement.

(8) The wire should be guarded against kinks.

(9) The wire should be oiled occasionally.

(10) The wire should be vertical when the top messenger is released.

(11) Never take station observations if wire has a slant of more than 35° with the sea surface.

(12) Allow five minutes after lowering the instruments before releasing the first messenger.

(13) Determine time interval for bottom bottle to be tripped at various depths and do not start hoisting until this interval has expired.

(14) Do not capsize bottles when removing them from wire.

(15) Read thermometers with great care and note registration in record book.

(16) Each bottle should then be returned to its properly marked stall in the rack in order of sequence.

(17) When last bottle is being hoisted on board, or before, plot the temperature readings of the various depths of observation on cross-section paper. If the values do not form a smooth curve characteristic for the time and place, repeat suspicious observations immediately before leaving station. Ability to detect errors in temperature curves comes with experience.

(18) Citrate bottles should be clearly marked to indicate the station number and the particular depth from which filled.

(19) Stoppers on citrate bottles should be absolutely air-tight.

(20) Coach oceanographic party in teamwork.

(21) Determine salinity of water samples by running them through the electric salinity tester on board and in accordance with instructions for same.

(22) Test salinity values on cross section for smooth curve.

(23) Apply to stem temperature of deep-sea thermometers the proper correction for auxiliary thermometer reading.

(24) Obtain density values by entering temperature and salinity graph.

(25) Test densities for smooth curve on cross-section paper. (See fig. 27, p. 88.)

A PROBLEM THAT HANDICAPS THE ICE PATROL

One of the most important natural problems which has confronted the ice patrol has been the securing of advance information regarding the probable drift of ice after arrival at the gateway to the Atlantic (the vicinity of the Tail of the Grand Bank). If we glance at a general map of the northwestern North Atlantic we may trace the general course followed both by the current and by the ice stream southwards along the continental slope from Baffin Land to the Tail of the Grand Bank without great change in direction for a distance of 1,800 miles. But when the cold Arctic water is discharged past the Tail of the Bank it is no longer preserved by the general trend of the continental slope, but is forced to meet directly the easterly moving masses of, or associated with, the Gulf Stream. It is at this point that the course of the current, and likewise its freight of ice, is subjected to great variations in direction. Naturally it is extremely desirable for the patrol to be able to disseminate to shipping, whether the ice will be deflected northward again into the shallow shelf waters, or whether it will be swept southward across the North Atlantic Lane Routes, and so create a very grave menace to shipping. If the patrol had knowledge of the drift tracks which bergs would follow after arrival at the gateway to the Atlantic, much more detailed information could be furnished to approaching vessels, especially during the protracted periods when fog enshrouds this cold-water region.

NEW METHODS IN OCEANOGRAPHY INTRODUCED ON ICE PATROL

The interdepartmental board charged with the administration of ice patrol had for some time been following the modern methods pursued in oceanography, particularly those taught at the Geophysical Institute, Bergen, Norway. The board believed that these methods had a practical application to the ice patrol's unique problem, as described in the preceding paragraph. The new thought in this branch of oceanography was more or less widely introduced by Prof. V. Bjerknes and others [1] in a treatise on the dynamics. Since that time several Scandinavian oceanographers have attained such success in further applying Bjerknes' basic formula to oceanographic investigations that arrangements were made for me to attend the Geophysical Institute, Bergen, 1924–25, for a year's study with Prof. Helland-Hansen on the theory of free motion and for instruction in the various methods of illustration. The oceanographic records of the ice patrol, some 3,000 observations of temperature and salinity from various depths and places in the ice regions, were also treated at the Geophysical Institute by mathematical computation. It is hoped to have this research published. The first maps thus ever

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[1] Dynamic Meteorology and Hydrography. Carnegie Inst. Pub., Washington, 1910–11.

drawn of the circulation in the ice regions indicate a close agreement between the calculated currents (velocity and direction) and the actual drifts of bergs at the time and place. Dynamic oceanography provides an easy and efficient means for mapping currents over extensive ocean surfaces, which guarantees it wide employment in future hydrographical surveys. If properly employed on ice patrol, moreover, it promises some day to vindicate the belief of the members of the London Convention which established the ice patrol, viz.:

> Skilled navigators and scientists are confident, partly as a result of Arctic and Anarctic explorations of recent years, that a thorough study and observation of ice conditions and formation, and of the Labrador current and other currents, the natural laws governing the formation and the movements of ice in the North Atlantic may be determined, at least to the extent of permitting approximate forecasts, similar to recent meteorological forecasts, which will contribute to safer ocean navigation.

If we steam the patrol vessel over the critical ice area, taking observations of the salinity and temperature at selected places, the data thus collected furnish the material for calculating the direction and velocity of the currents.[2]

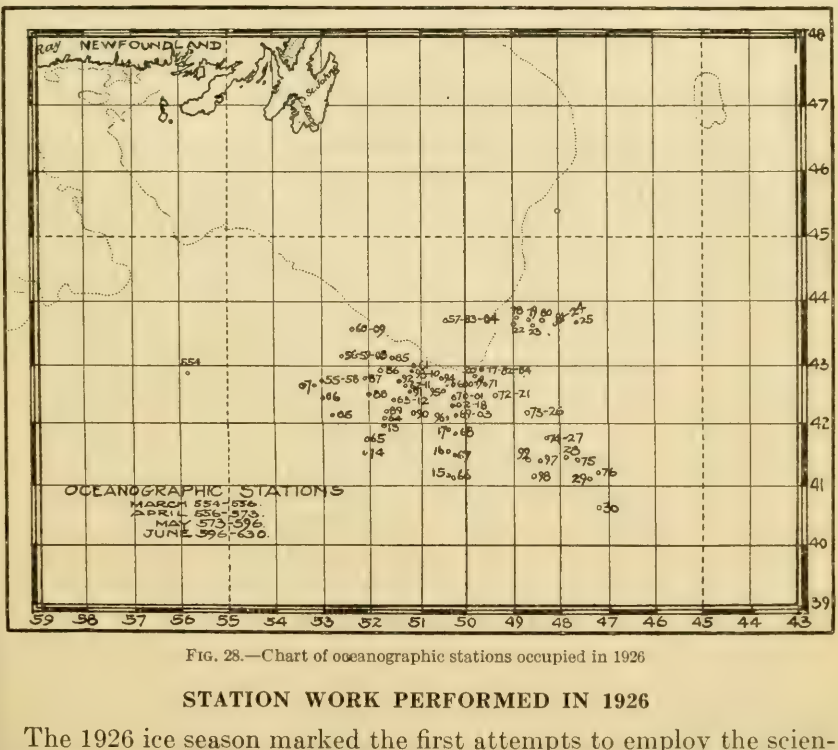

FIG. 28.—Chart of oceanographic stations occupied in 1926

STATION WORK PERFORMED IN 1926

The 1926 ice season marked the first attempts to employ the scientific methods explained in United States Treasury Bulletin No. 14,

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[2] Smith, Edward H.: A Practical Method for Determining Ocean Currents. U. S. Treas. Dept. Bull. No. 14, 1925.

32036—27——7

and the work was bent wholly towards contributing direct practical information on the behavior of those icebergs that drifted south of the Tail of the Grand Bank. In the course of the season a total of 76 stations were taken, all but three of which were occupied in the deep water off the slope to a depth of 750 meters. This number of stations is less than for 1923 or for 1924; but their value was consequently greatly enhanced by their being well distributed over the area to be surveyed, with each station in the set taken in rapid succession. We were handicapped during the early part of the season by the breaking down of the oceanographic winches on board both the *Tampa* and the *Modoc*, so that the first set of stations was not actually begun until April 29, after the patrol had been in progress more than a month. It was deemed best to make a general survey of the entire ice area at the beginning of the season and a second one at its close. During the progress of the season it was not found possible to make more than one survey and this was confined to a comparatively small but important area off the southwest slope of the Bank. The critical ice area is of such great extent that it requires at least a total of 12 to 14 stations to delineate the courses of the currents with any accuracy. A satisfactory survey of the entire region around the Tail was afforded by Sets I and III with a total of 26 stations.

SOME FEATURES REVEALED BY THE VERTICAL SECTIONS

The vertical sections show the distribution of temperature, salinity, and specific volume for the following groups of stations:

Section I: West-southwest slope, stations 558–560, figures 29 and 30.

Section II: Southwest slope, stations 557–565, figures 31 and 32.

Section III: South slope, stations 566–570, figures 33 and 34.

Section IV: Southeast slope, stations 571–576, figures 35 and 36.

Section V: East slope, stations 578–581, figures 37 and 38.

Section VI: West-southwest, station 607–609, figures 39 and 40.

Section VII: Southwest slope, station 610–614, figures 41 and 42.

Section VIII: South slope, station 615–619, figures 43 and 44.

Section IX: Southeast slope, station 620–630, figures 45 and 46.

Section X: East slope, station 622–625, figures 47 and 48.

Since vertical sections normal to the Grand Bank slopes have been taken and discussed repeatedly in former ice seasons, only brief comment on the principal features is called for.

Section I: The striking thing about this profile, Figure 29, is the shelf of icy water (temperature below 0° C.), that hugged the slope between 100 and 200 meters, and extended out about 20 miles from the edge. The density wall, as illustrated in Figure 30, was well developed at the time with its highest point approximately 45 miles seaward from the slope.

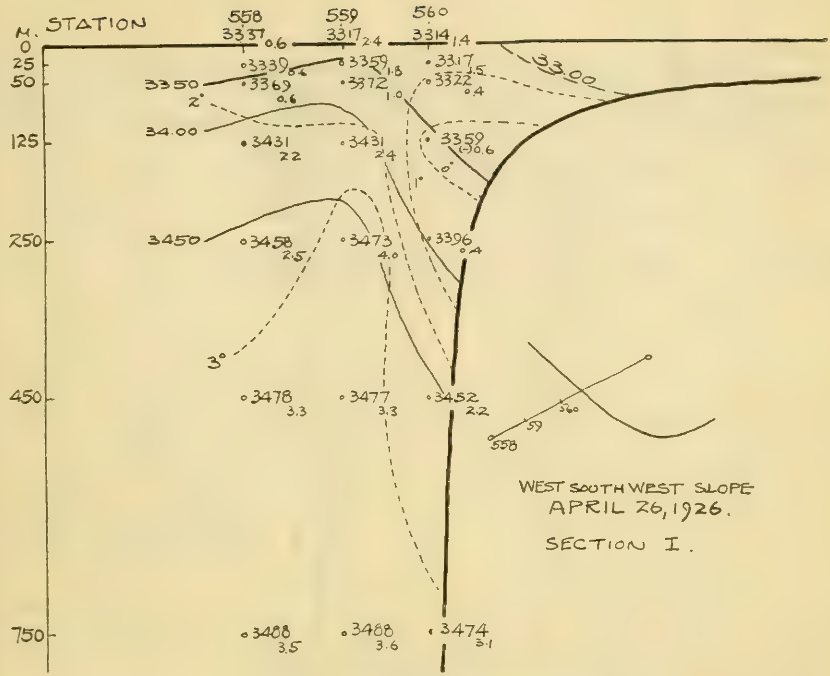


FIG. 29.—Distribution of temperature and salinity

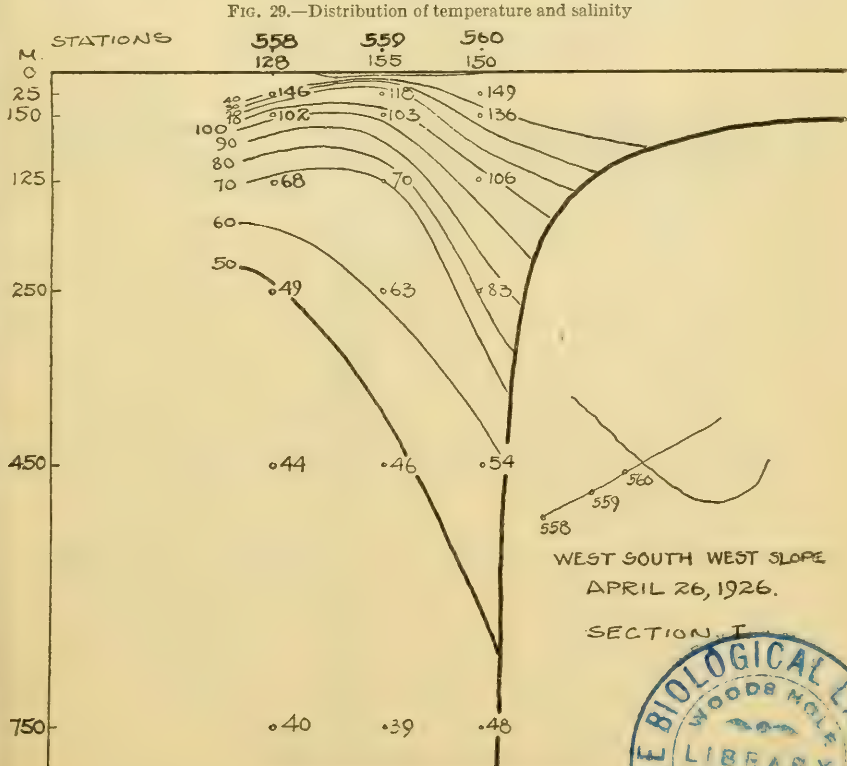


FIG. 30.—Distribution of specific volume

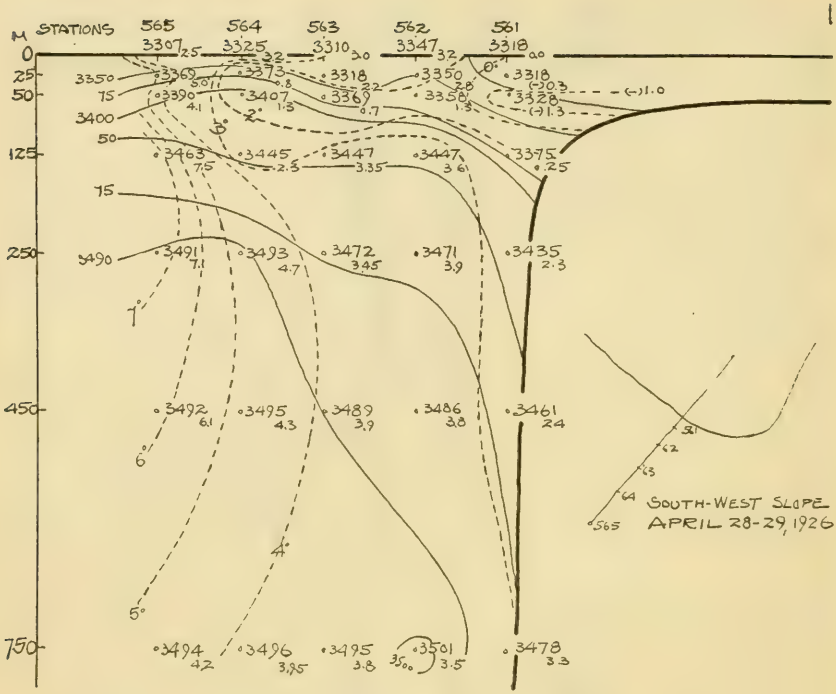


FIG. 31.—Distribution of temperature and salinity

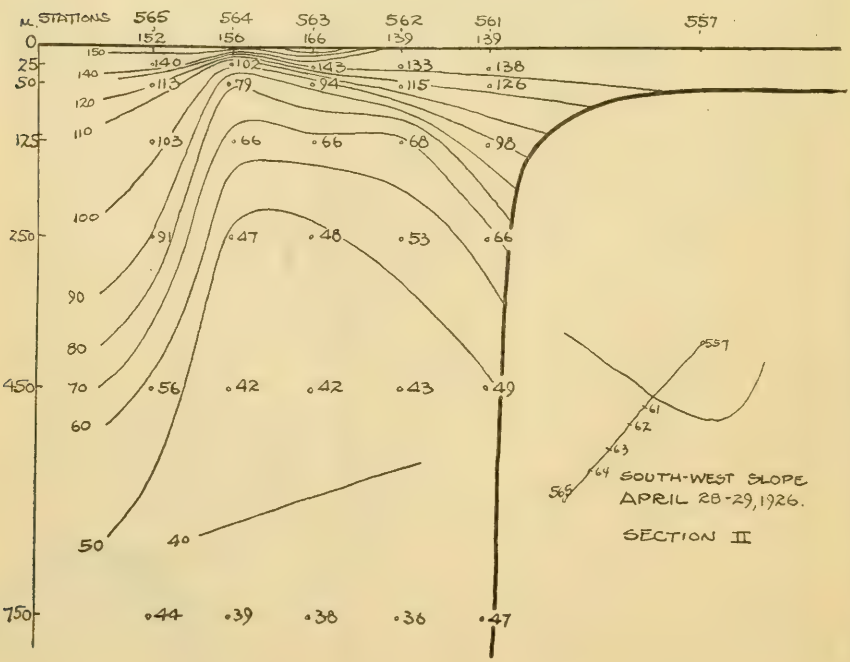


FIG. 32.—Distribution of specific volume

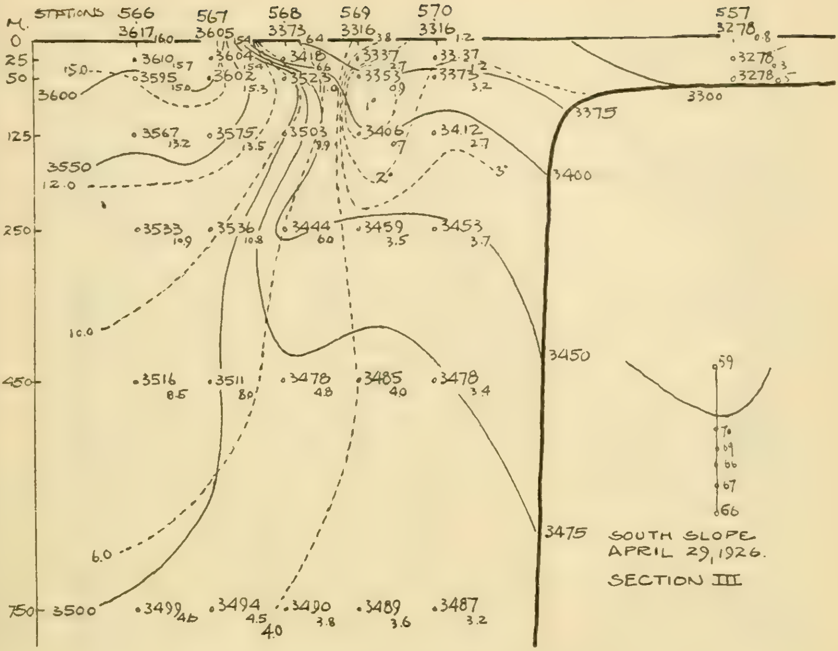


FIG. 33.—Distribution of temperature and salinity

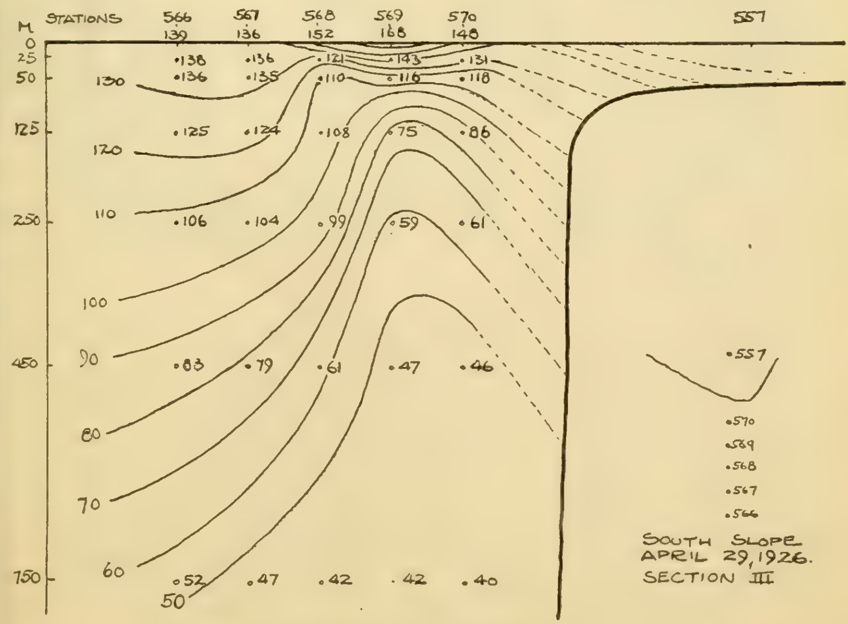


FIG. 34.—Distribution of specific volume

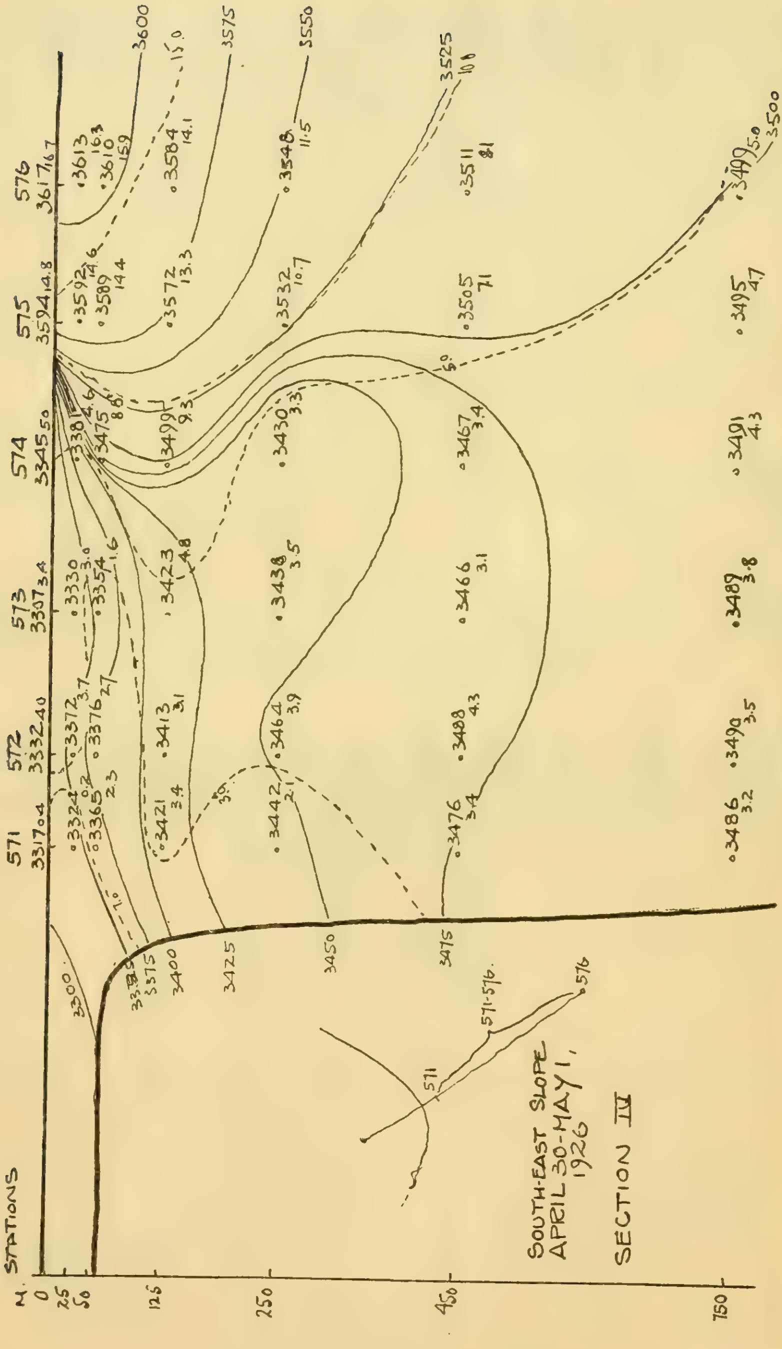


FIG. 35.—Distribution of temperature and salinity

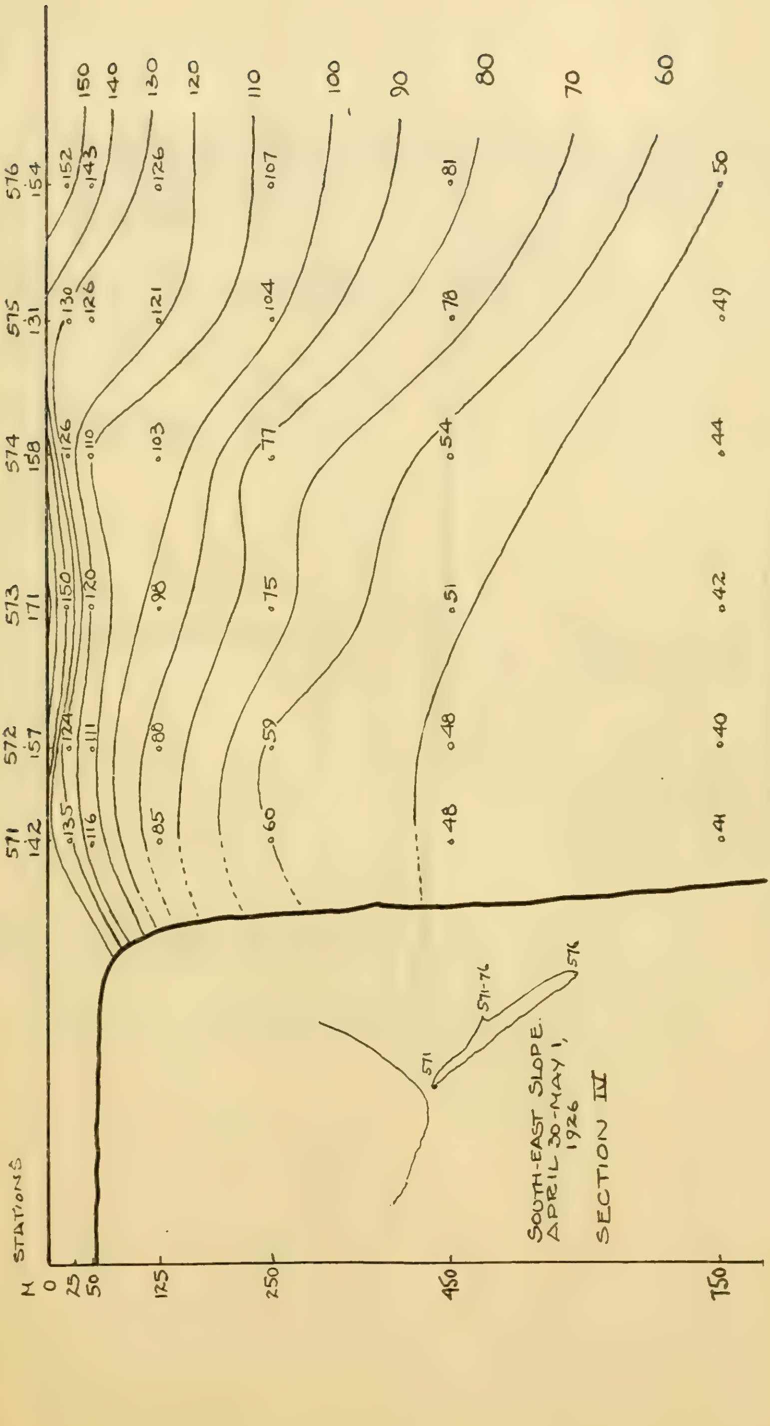


FIG. 36.—Distribution of specific volume

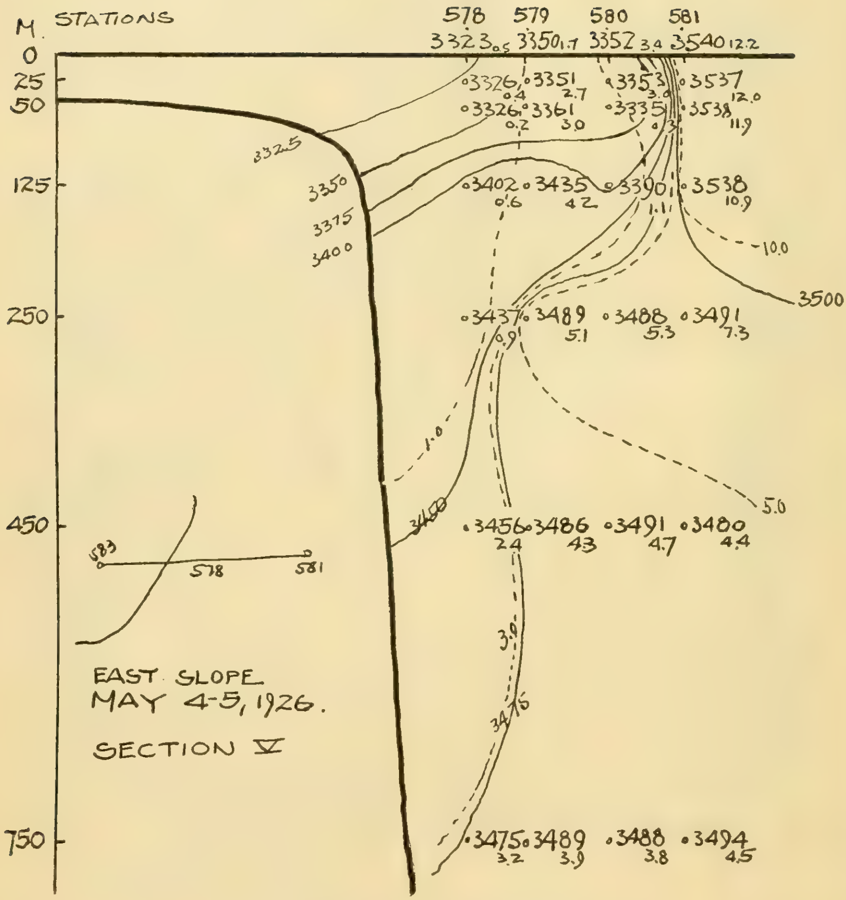


FIG. 37.—Distribution of temperature and salinity

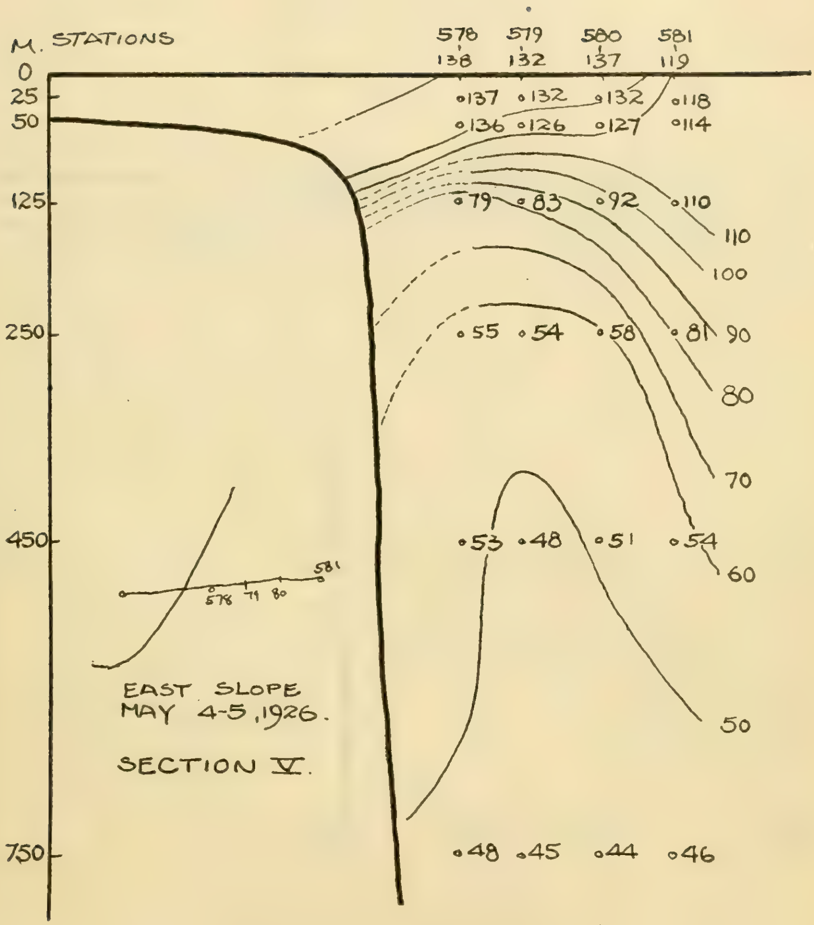


FIG. 38.—Distribution of specific volume

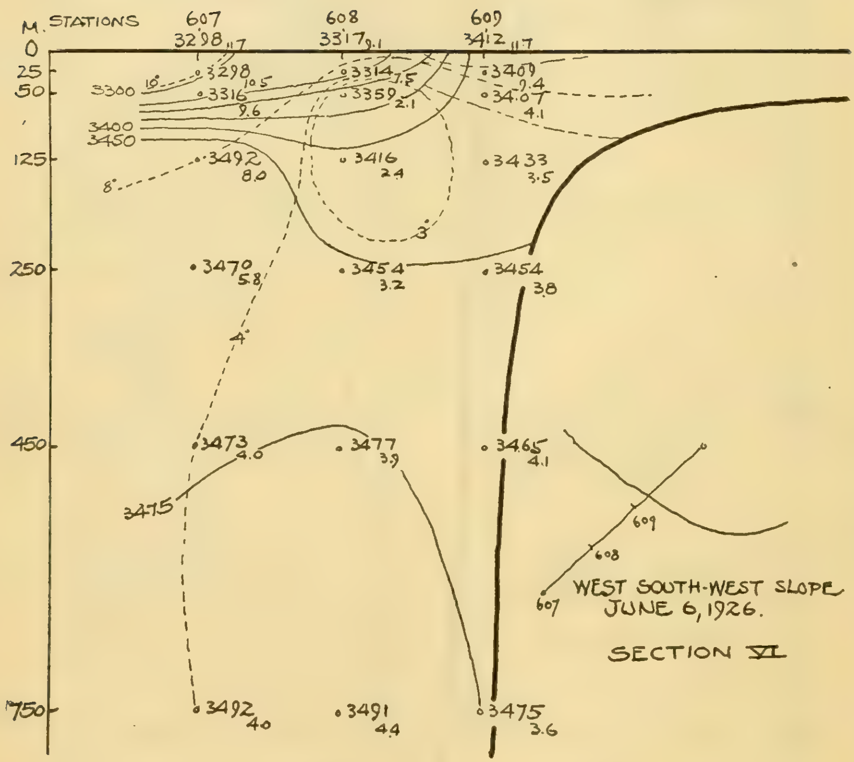


FIG. 39.—Distribution of temperature and salinity

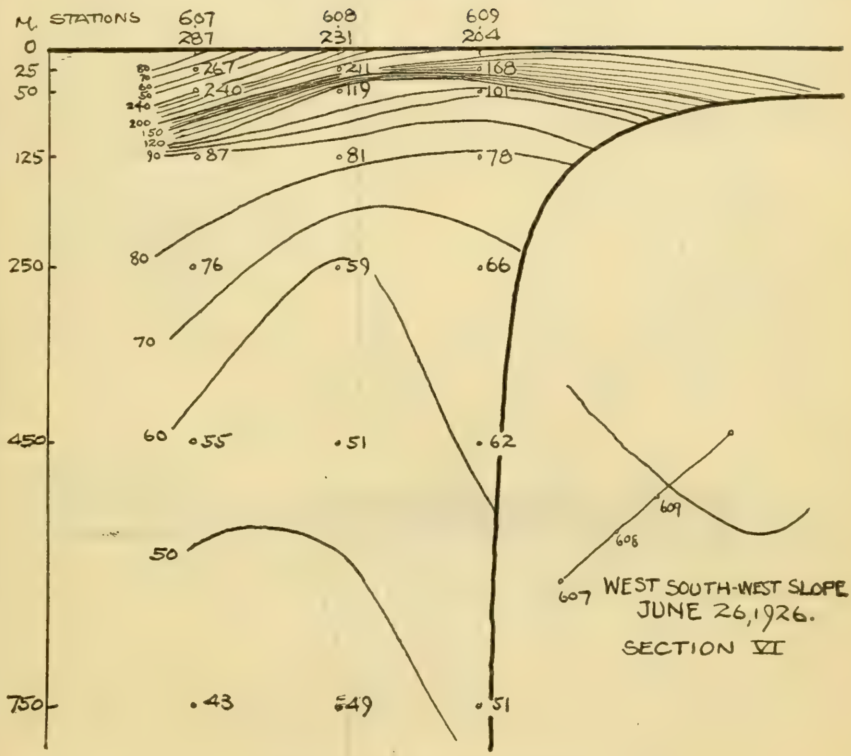


FIG. 40.—Distribution of specific volume

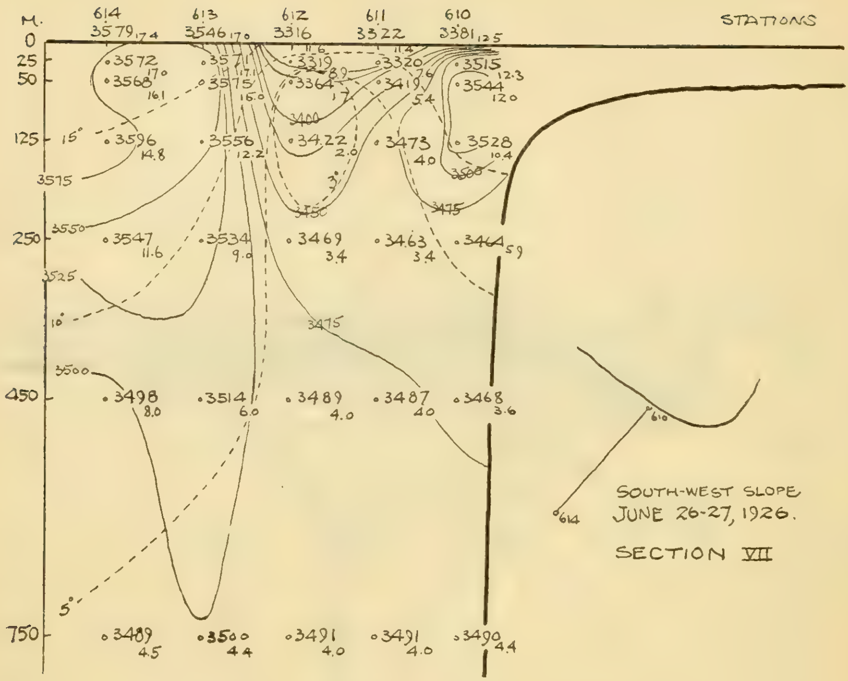


FIG. 41.—Distribution of temperature and salinity

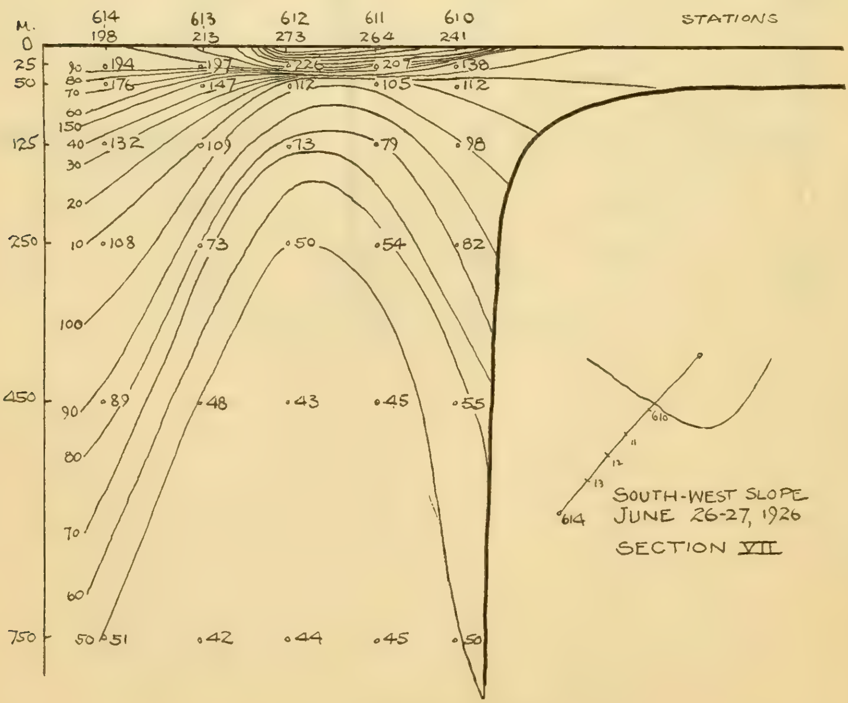


FIG. 42.—Distribution of specific volume

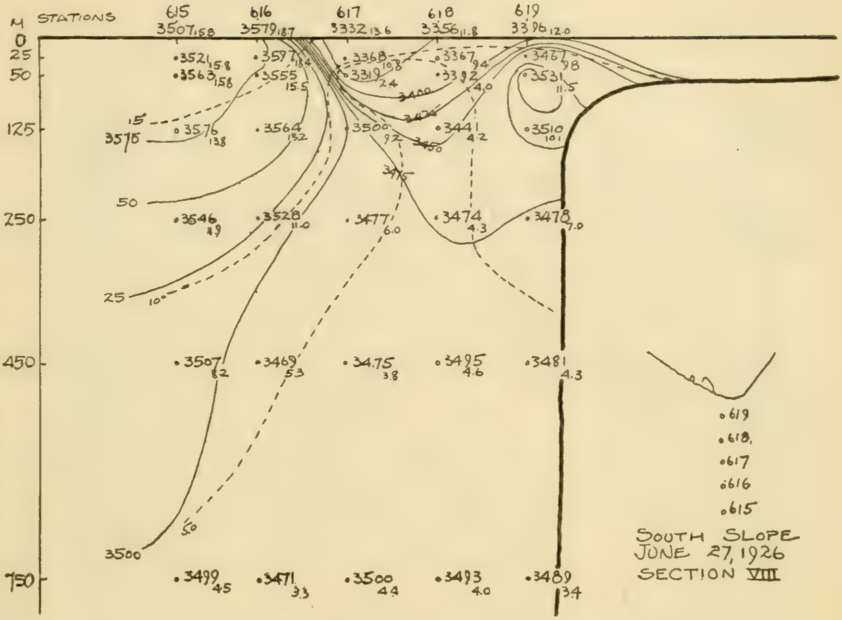


FIG. 43.—Distribution of temperature and salinity

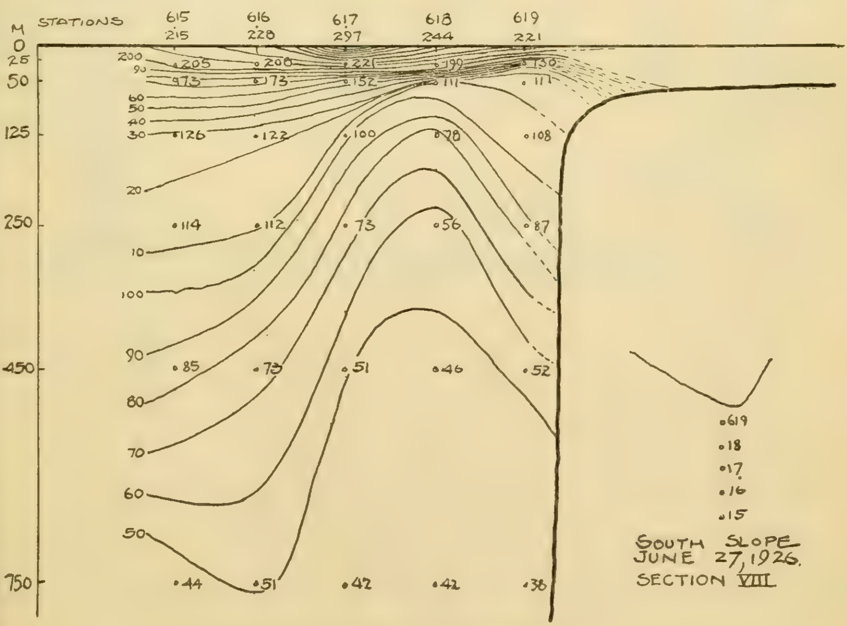


FIG. 44.—Distribution of specific volume

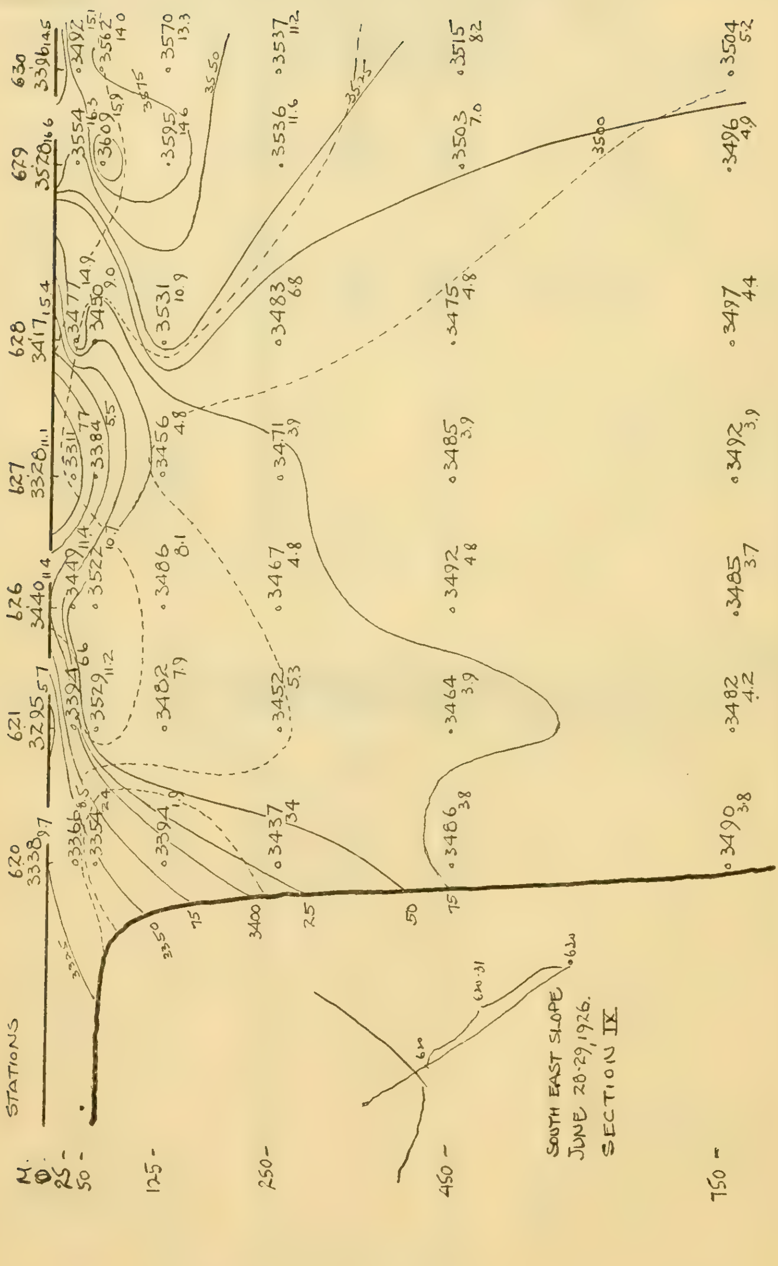


FIG. 45.—Distribution of temperature and salinity

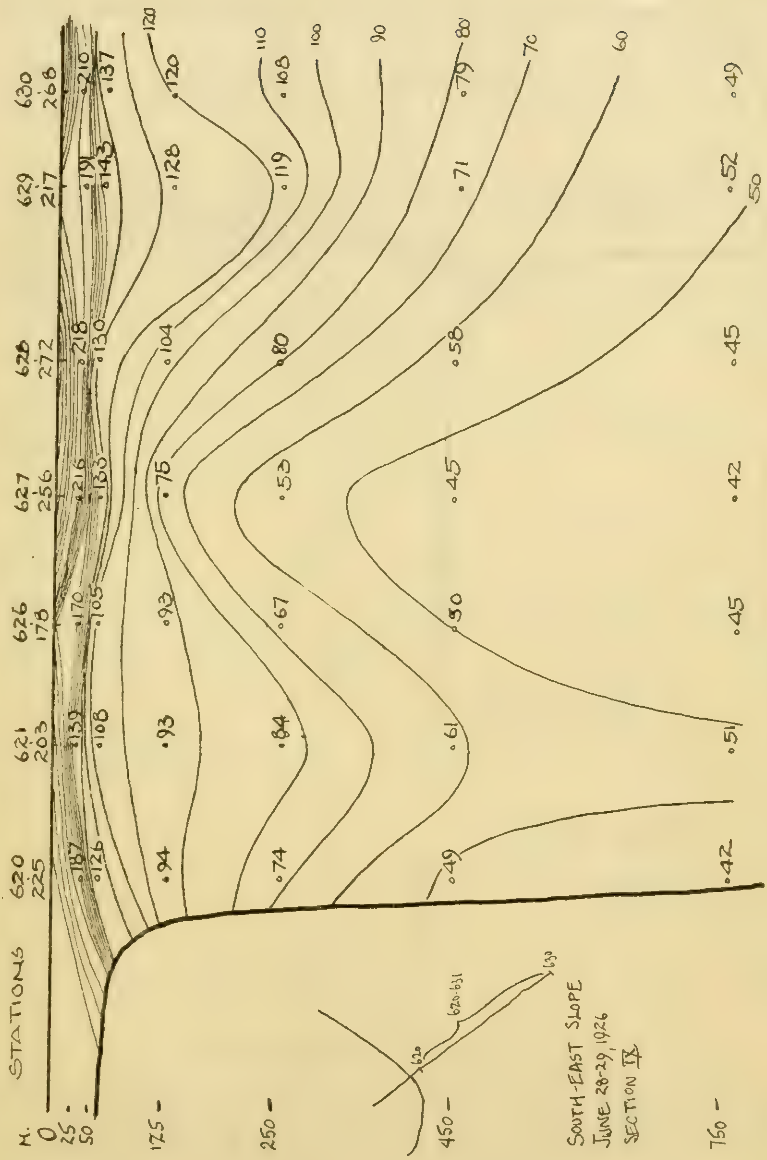


FIG. 46.—Distribution of specific volume

Section II: A cold surface layer 125 meters in thickness spread out from the edge for a distance of 75 miles. The corresponding profile anomaly of specific volume, Figure 32, indicates a much steeper slope to the isosteres on the offshore side of the density wall than on the inshore.

Section III: No water colder than 0° C. was found at the Tail on April 29, despite the fact that water colder than zero was then

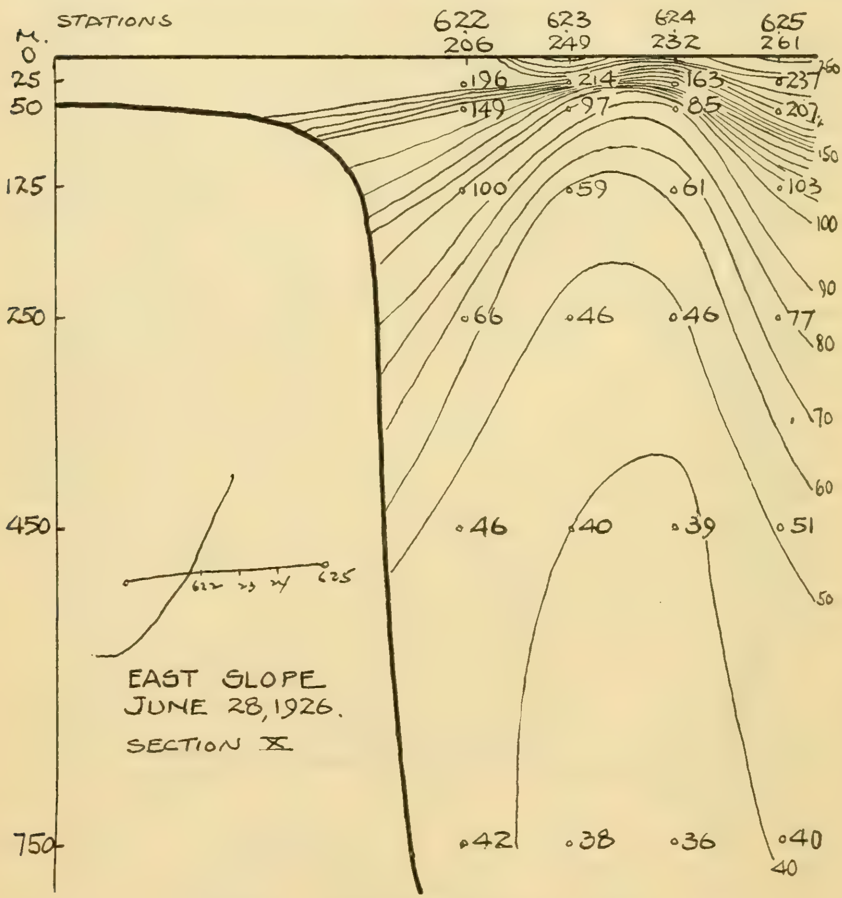


FIG. 47.—Distribution of temperature and salinity

bathing the slope farther to the northwest. The coldest water at the Tail, 1°, then took the form of a closed core at a depth of 50 to 100 meters, situated about 45 miles off the slope. The warm salty water at the outer end of this section is unmistakably that of the Gulf Stream. The density wall, as shown by Figure 34, page 95, was then well developed located near station 569, 45 miles offshore from the Tail. A comparison of Figures 33 and 34, page 95, indicates that the density wall

was then approximately 25 miles inshore of the "cold" temperature wall.

Section IV: No extremely cold water was found in this section, but the offshore stations 575 and 576 showed the effects of warm tropical water. The isosteres have a gentle, irregular slope from the inshore station, 571, out to the very end of the picture.

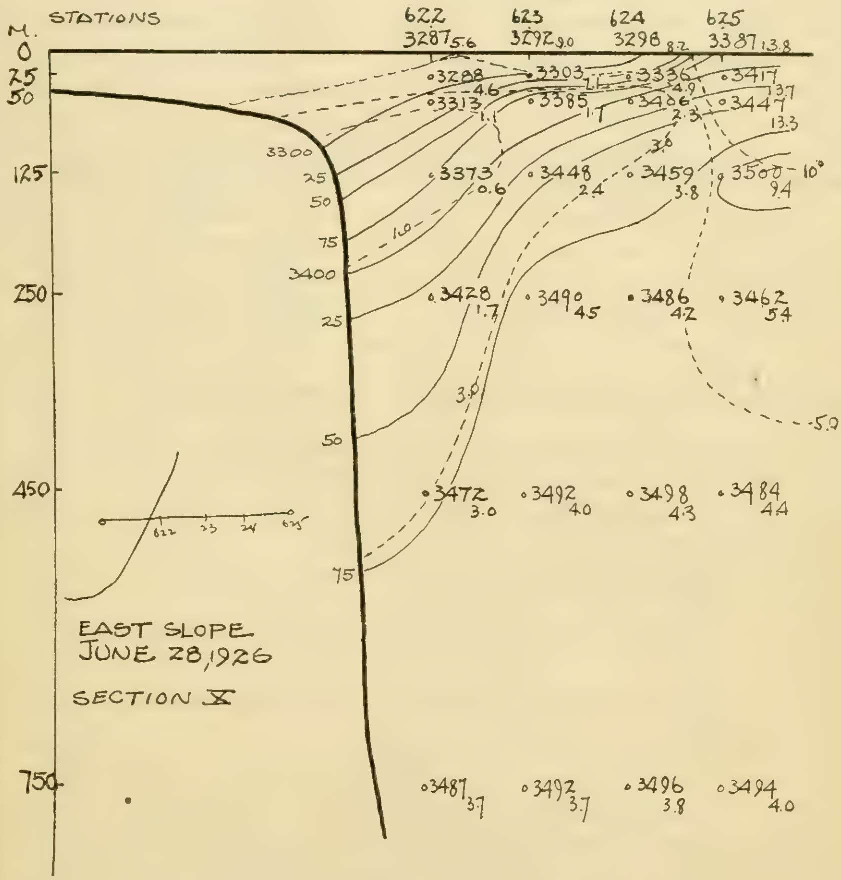


FIG. 48.—Distribution of specific volume

Section V: The inner edge of the Gulf Stream was reached at station 581 while the inshore stations showed no water colder than 0° C. The density wall lay 25 miles inside of the "cold" temperature wall. (Cf. fig. 37 with fig. 38, pp. 98, 99.)

Section VI: To our surprise a pool of relatively warm and fresh water was found at the offshore station on this section. It is difficult, to explain its source unless it had drifted out from the Grand Bank, curling around the end of the cold current which usually extends northwestward along the slope from the Tail, at that season. Doubt-

less the body of warm salty water which bathed the slope inshore on this section had its source in the inner edge of the Gulf Stream, the development of this invasion is plainly discernible on the horizontal charts of circulation. The increased number of isosteres in the profile of specific volume (fig. 40), over what were present in this locality six weeks earlier (fig. 30) represents the influence of increased solar warming of the surface layers.

Section VII: A connection with the warm salty water observed in Figure 39, is to be observed in this section (fig. 41) at the slope stations. The high temperatures and salinities at the two outer stations plainly indicate that the northern edge of the Gulf Stream then lay approximately 75 miles off the southwest slope. The density wall (fig. 42) was 20 to 25 miles inshore of the cold wall.

Section VIII: Again in this section we see a trace of tropical water along the southwest slope wedged in against the bank. The density wall at the Tail was about 30 miles inside of the temperature wall.

Sections IX and X exhibit no unusual characteristics from those observed in earlier sections at the same places.

DISCUSSION OF THE CIRCULATION IN THE HORIZONTAL PLANE

The total of 76 stations have, for the purposes of horizontal illustration, been divided into three groups which are separated from one another by a space of at least two weeks in time. They have been arranged as follows:

Set I: April 29 to May 5, a total of 25 stations embodied in Figures 49, 50, 51, 52.

Set. II: May 18 to 20, a total of 13 stations embodied in Figures 53, 54, 55, 56.

Set III: June 25 to 29, a total of 27 stations embodied in Figures 57, 58, 59, 60.

SET I

The 175 density values obtained from 25 stations, 558 to 583, taken April 29 to May 5, were subjected to mathematical computations described in United States Treasury Department Bulletin No. 14, giving the values shown in the last four columns in the oceanographic station table, page 78. Since we assumed that the maximum depth of observation, 750 meters (or decibars), was a level isobaric plane, the dynamic values of 728 + given on the charts (figs. 49, 53, and 57) represent the height of the sea surface in dynamic meters at each station. (See Oceanographic station table, p. 78, for a detailed record of these data.) The dynamic heights have been plotted at the proper station positions on Figure 49, page 109, and contour lines delineating the topography of the sea surface were drawn in similar fashion to those which appear on an ordinary

isobaric weather map. The dynamic topographical map (fig. 49) is read also in the same manner as one reads a meteorological map. The oceanic situation around the Tail of the Grand Bank April 29 to May 5 may be described as follows: A "low" or hollow in the sea surface lay centered off the southwest slope of the Grand Bank with a trough, circumscribed by the contour of 728.70 dynamic meters, extended around the Tail to the northeastward more or less paralleling the 100-fathom curve. The sea surface was relatively high in over the Bank itself and at the outermost stations offshore. A hill of water, figuratively, lay centered about 65 miles southeastward of the Tail.

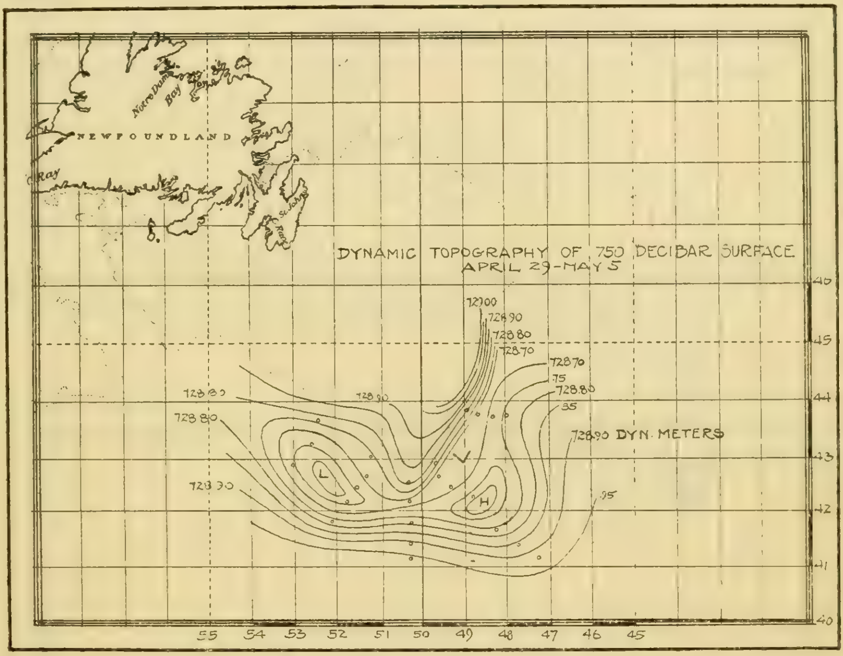


FIG. 49.—Set I. Dynamic topographical map

The circulation of the water, which will follow this dynamic topography of the surfaces is in general as on a weather map, anticlockwise around the "lows" and clockwise around the "highs." Figure 50, page 110, indicates the direction of flow of the water by means of the arrows, and the numerals represent in knots per hour the velocity of the current at the particular place and time. The velocities were calculated upon the assumption that the water had no motion at a depth of 750 decibars (meters). Such, however, was not literally the case, especially offshore in the Gulf Stream, but inasmuch as 750 decibars was the limit of depth to which our observations extended, it is taken arbitrarily as the depth at which motion most nearly approached zero. Reference to Figure 50, page 110, shows

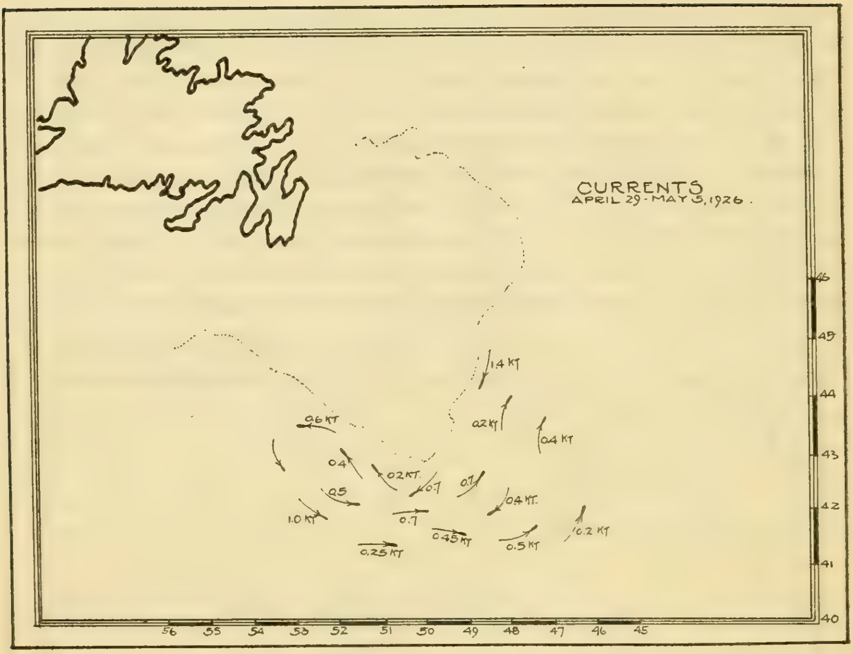


FIG. 50.—Set I. Direction and velocity of the currents

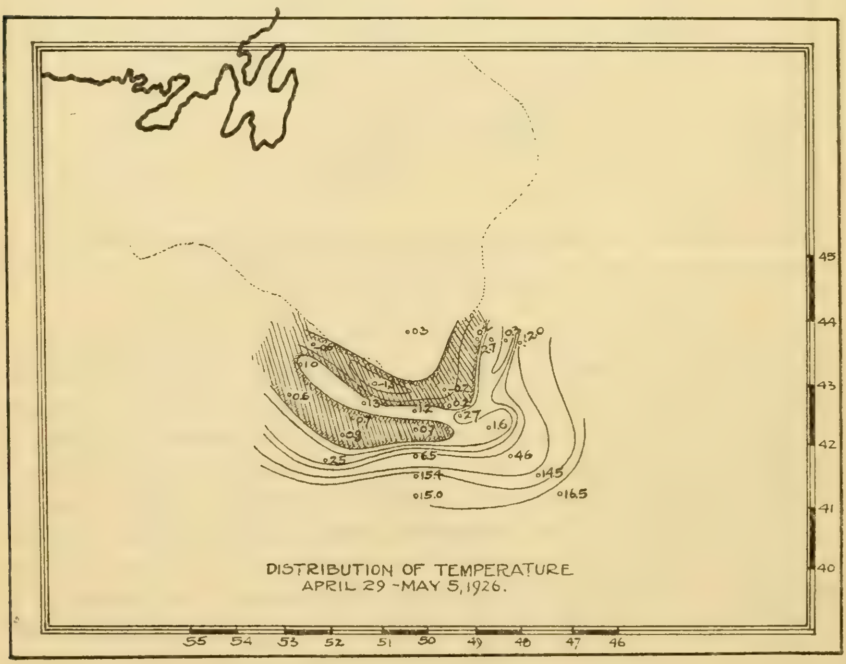


FIG. 51.—Set I. Distribution of cold and warm water

that the cold current was running swiftest along the east side of the Bank at the rate of 1.4 knots per hour, but it decreased to 0.7 knot 60 miles farther south at the Tail. The inshore set (Labrador current) curled around the Tail and flowed northwestward parallel with the continental edge, a distance of 150 miles, as far as our observations extended in that direction. Reaching that locality, a great portion of the current eddied offshore and back to the eastward, forming a vast anticyclonic vortex off the southwest slope. The most rapid rate of flow was 1 knot, located southwest of the Bank, as shown on Figure 50, page 110. The easterly moving water masses were split by a clockwise eddy when they reached a point

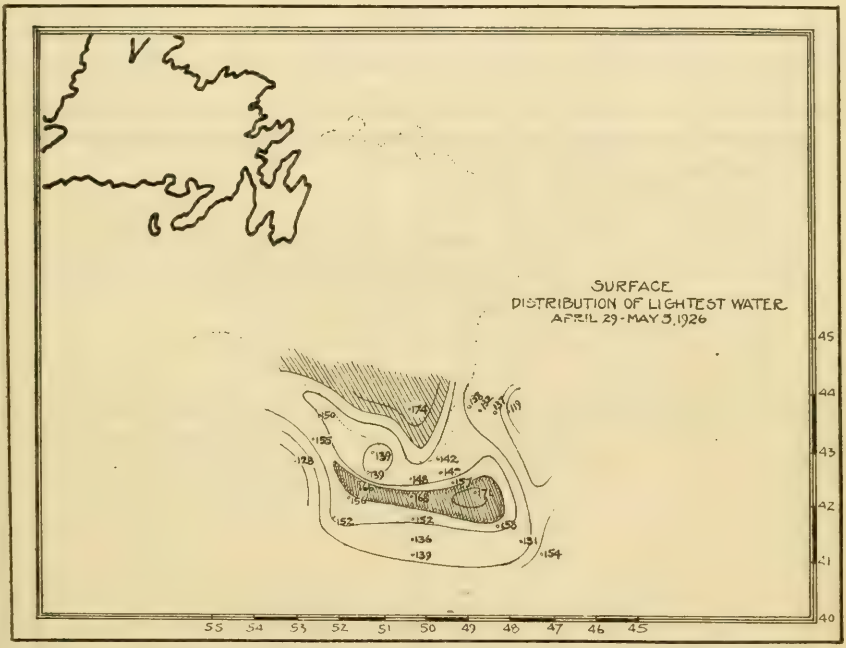


FIG. 52.—Set I. Distribution of light and heavy water on the surface of the sea

southeast of the Tail, but just to the northeast of this point the branches rejoined. The northeasterly counterset was only 25 miles off the eastern edge of the Bank in latitude 44°, but it was weak—0.2 of a knot per hour.

The distribution of cold water, as shown by Figure 51, page 110, is good evidence which supports the general scheme of circulation calculated and portrayed on Figure 50, page 110. The cold water from the north was transported to the Tail and thence along the southwest slope of the Grand Bank as far as our observations in that direction extended. The shape and position of the shaded area of water less than 1° C. (fig. 51, p. 110), clearly indicates that this cold water after being brought to the region of tbe southwest slope was

carried back to the eastward in the form of a counterset, separated from the westerly moving stream inshore by a strip of water about 10 miles in width and with a temperature higher than 1°. The fourth sketch of this set of observations, April 29 to May 5 (fig. 52, p. 111), illustrates the distribution on the surface around the Tail of the lightest water.

The lightest water, which has been inclosed in a shaded area, extended parallel with the slope some 35 miles to the seaward of the 100-fathom contour and had heavier water on either side. Light water also was found in over the Bank itself.

SET II

A hollow in the sea surface, the center of which was 10 dynamic centimeters lower than at any other point around the Tail, is to be

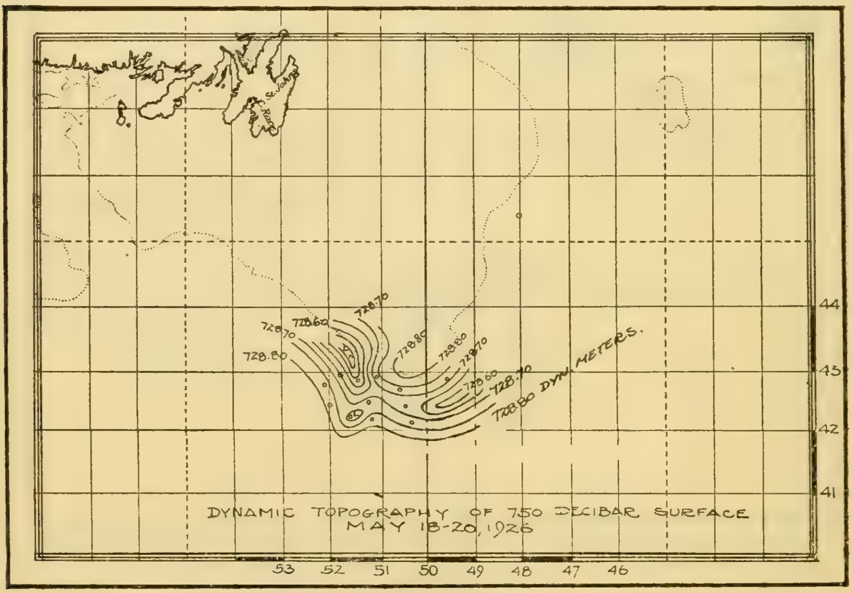


FIG. 53.—Set II. Dynamic topographical map

noted on Figure 53. The same trough of 728.70 dynamic meters that was recorded around the Tail of the Bank two weeks earlier is seen here stretched along the slope. The sea surface was relatively high in over the Bank and offshore at the outer stations, all of which conditions agree with those previously observed this season.

The oceanic situation for May 18 to 20 (fig. 53) reveals the fact that an important change had taken place since the first week in May (fig. 49). These two figures show that the spacious vortex observed in the sea surface off the southwest slope April 29 to May 5 had been pushed up against the edge of the Bank by a force acting

FIG. 54.—Set II. Direction and velocity of the currents

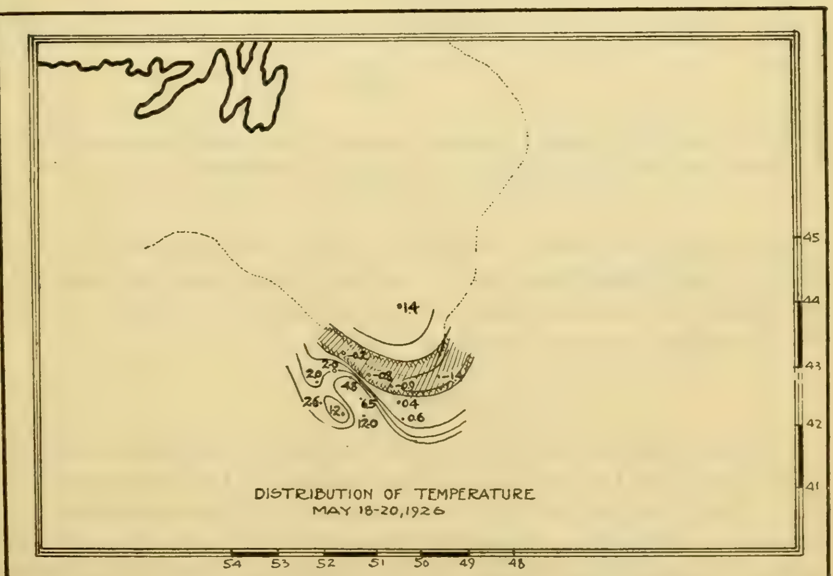


FIG. 55.—Set II. Distribution of cold and warm water

from offshore to the southwest, and this action, moreover, had tended to deepen the vortex by about 10 dynamic centimeters. The steepening of the sides of this hollow had correspondingly intensified the currents around the center so that velocities as high as 1.3 knots per hour are recorded on Figure 54. The distribution of critical temperatures on Figure 55 discloses a wedge of warm water had invaded the locality immediately off the southwest slope from offshore. The western side of the picture shows cold inshore water of northern origin curling around the western extremity of this warm wedge to the southeastward, so that the birth of an anticyclonic

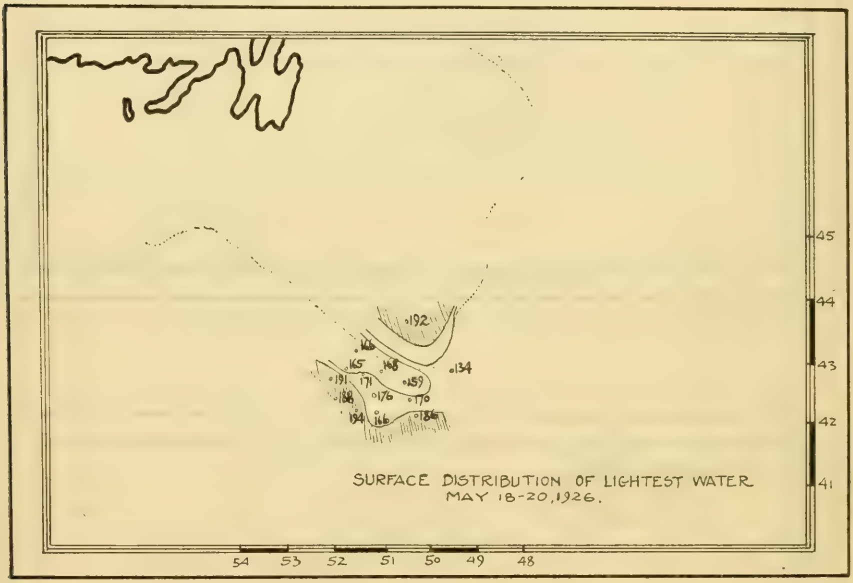


FIG. 56.—Set II. Distribution of light and heavy water on the surface of the sea

rotating eddy is clearly indicated off the southwest slope of the Bank. The lightest water on the surface lay in over the Bank and also offshore at the outer stations, a distribution very similar to that which prevailed two weeks earlier.

SET III

A study of the dynamic topographical map for the period June 25 to 29 shows that the hollow in the sea surface off the southwest slope of the Bank (figs. 49 and 53) had again expanded to about the same form as in early May, except for being slightly more elongate and curling a few miles further to the eastward. A trough extended southward paralleling the east slope of the Bank and at a distance out about 50 miles. The direction and velocity of the currents are shown on Figure 58 as also the drift of two bergs which were sighted

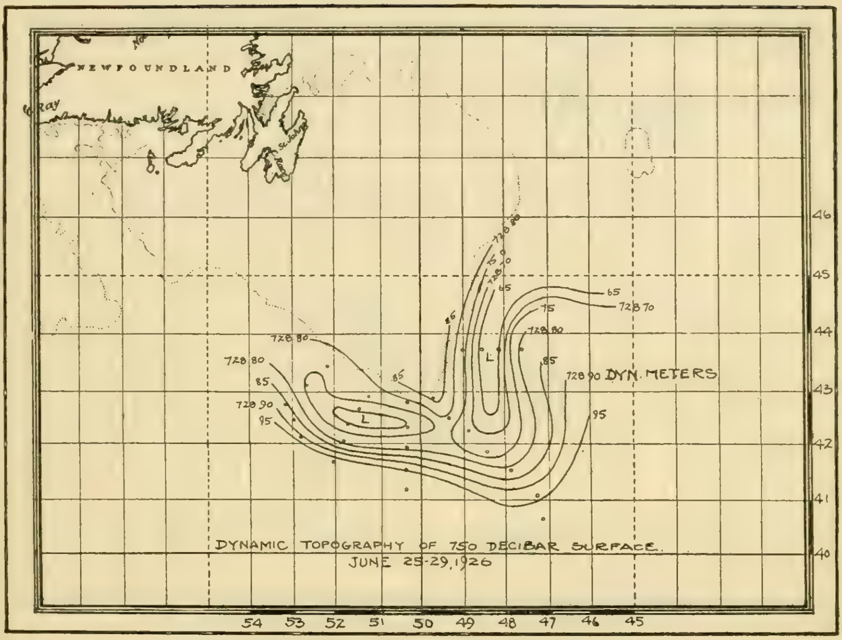


FIG. 57.—Set III. Dynamic topographical map

FIG. 58.—Set III. Direction and velocity of the currents

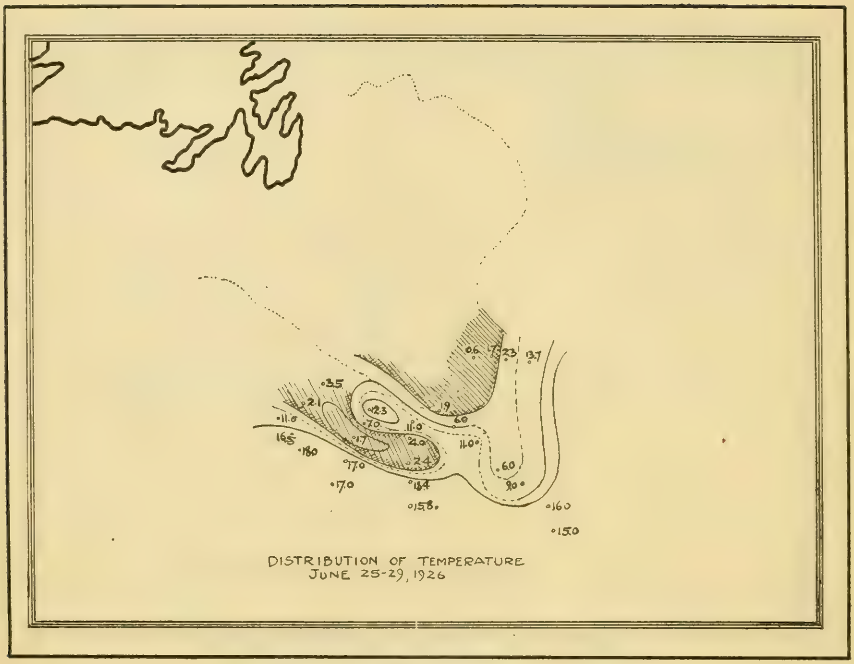


FIG. 59.—Set III. Distribution of cold and warm water

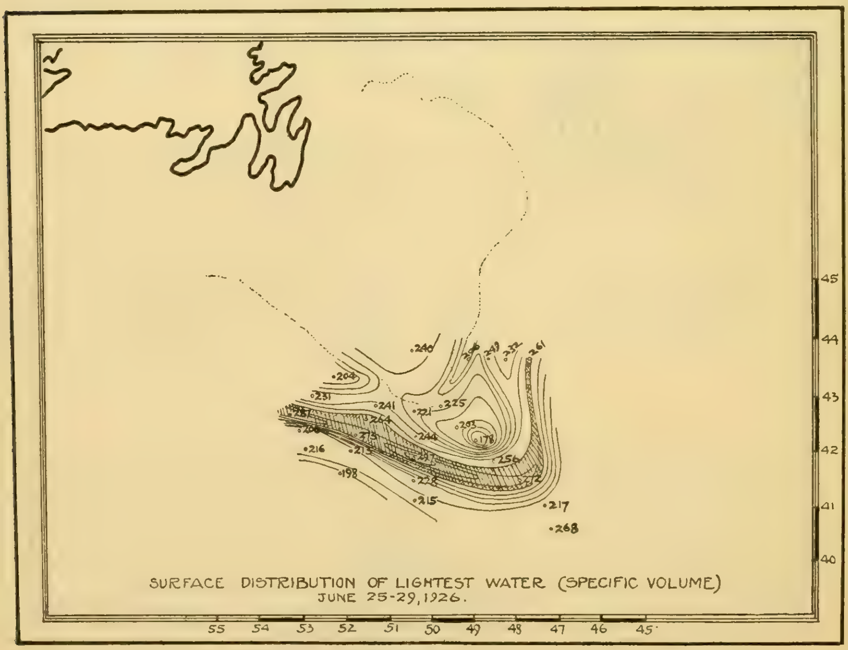


FIG. 60.—Set III. Distribution of light and heavy water on the surface of the sea

in the area at the time. The behavior of the ice conforms as might be expected to the circulation as denoted on the map. The distribution of temperature as plotted on Figure 59 plainly shows that warm water previously mentioned on Figure 55 had worked its way to the northwestward along the Bank slope, while on the other hand cold water from the north curled offshore 150 miles or so westward of the Tail, finally to be carried along in a return stream to the eastward, 30 to 40 miles off the continental edge. A comparison of this map with the two earlier temperature charts, Figures 51 and 55, shows the development of this rotating movement of the warm and cold waters. The lightest surface water (fig. 60) was in the form of a band 25 to 30 miles in width and more or less paralleling the Bank contour about 60 miles offshore. The effect of solar warming of the surface layers during the latter part of June is clearly shown by the increase in values for the specific volumes from those collected for May. (Fig. 52.)

SUMMARY

The work this year marks the first attempt at dynamic calculation of ocean currents on board a surveying vessel immediately following the collection of the data and also the employing of such information at once for the benefit of passing ships. The three sets of observations (figs. 49, 53, and 57) permit us to follow the changes that took place in the circulation around the Tail of the Bank from April 29 to June 30. First, we may regard the circulation as found by the earliest survey as more or less characteristic of the waters around the Tail of the Grand Bank. On or about May 15 warm salty water from offshore interrupted this scheme of circulation by pushing in toward the southwest slope and pinching off the flow of Arctic water that normally drifts clockwise around the Atlantic face of the Grand Bank. This movement characterizing the currents in May had slackened before the latter part of June, and the scheme of circulation had returned to what we regard as normal. Except for this unexplained interruption the cold current continually flowed around the Tail and to a variable distance (approximately 150 miles), along the southwest slope where it turned to the eastward, joining the warm current known as the Gulf Stream. This distribution and direction of the currents tended to form a great anticyclonic eddy off the southwest slope of the Grand Bank.

RELIABILITY OF CURRENT MAPS

One of the problems upon which we wished to gain information as a result of the season's work, was the rate of change in direction and velocity of ocean currents, to tell whether one survey a month would serve all practical purposes or whether rapid changes in the circulation would make more frequent surveys necessary. There have been

very little data collected from the ocean which throw much light on this subject. In case we argue from the atmosphere we know that isobaric maps as much as 24 hours old contain little information on the situation for the present. The scheme of oceanic circulation around the Tail of the Bank this season altered quite noticeably within a space of two weeks and then resumed, broadly speaking, its original state, all within the priod of two months. It is hoped that the same plan of oceanographic work introduced in 1926 is continued for a few years so that we shall be in a position to say considerable more on the reliability of current maps with the elapse of time.

DISSIMILARITY BETWEEN DENSITY AND COLD WALLS

The observations in 1926 corroborate earlier ones to the effect that the density of the water around the Grand Bank is usually higher along the zone of contact between the Labrador current and the Gulf Stream than on either side of the latter. But this density wall does not exactly coincide in location with the zone of most abrupt transition from low to high temperature (the cold wall), but lies as a rule 25 to 35 miles inshore of the latter. Since the density wall unquestionably marks the boundary between the easterly and westerly sets, this discovery means that the drop in the temperature of the surface water near the continental slope does not mark the change in the direction of the current.

LIGHT WATER COLLECTS ON SURFACE OF THE SEA

Evidence has been accumulating that there is a prevailing tendency for relatively light water to collect on the surface of the sea immediately over the belt of the heaviest subsurface water, represented by the density wall; this has been observed in the profiles of every ice season since 1922, so it must be more than a coincidence.

DRIFT OF BERGS CHECKED WITH CALCULATED CURRENTS

We were handicapped this year by fog in comparing the drift of the bergs with the currents calculated and plotted, but the few examples obtained have been found to harmonize. (Fig. 21, p. 73.) The fact that there were few opportunities to make comparisons in the case of specific bergs ought not to be interpreted as detracting from the value of the three sets of illustrations represented by Figures 49, 53, and 57, all of which were continually consulted by those in charge of maneuvering the patrol ships.

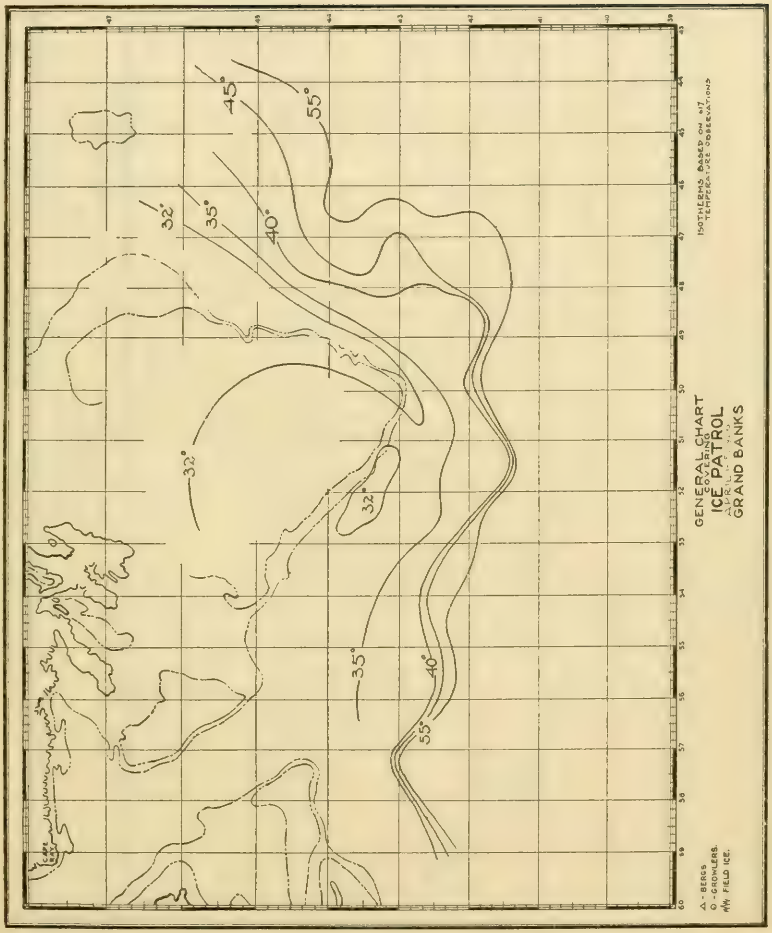


FIG. 61.—Distribution of temperature on the surface April 1 to 15

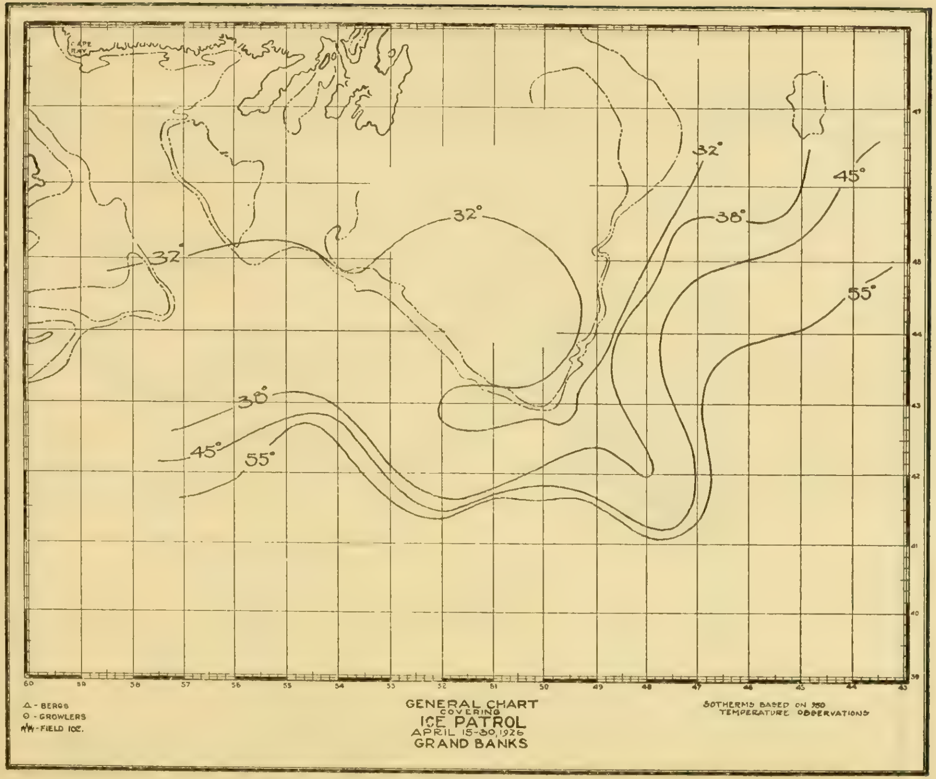


FIG. 62.—Distribution of temperature on the surface April 15 to 30

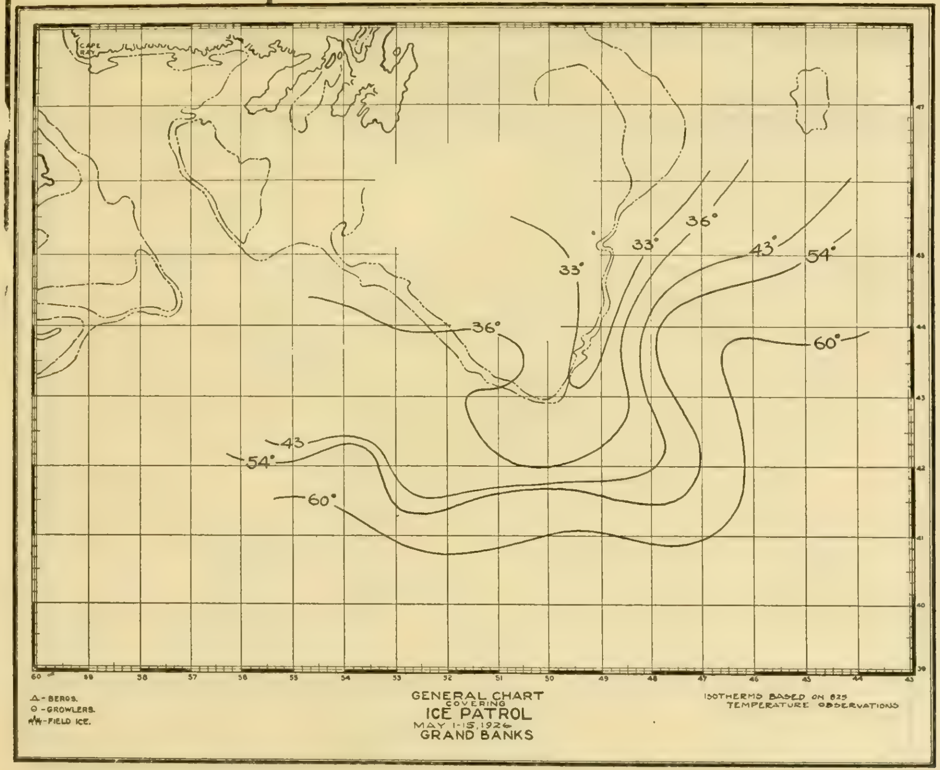


FIG. 63.—Distribution of temperature on the surface, May 1 to 15

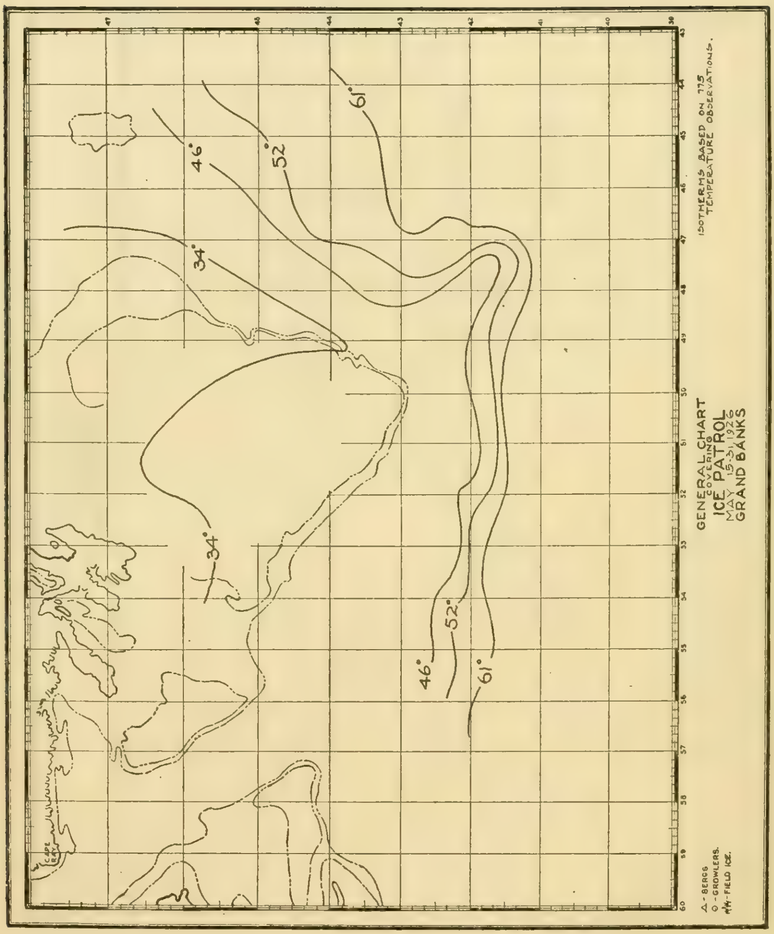


FIG. 64.—Distribution of temperature on the surface, May 15 to 31

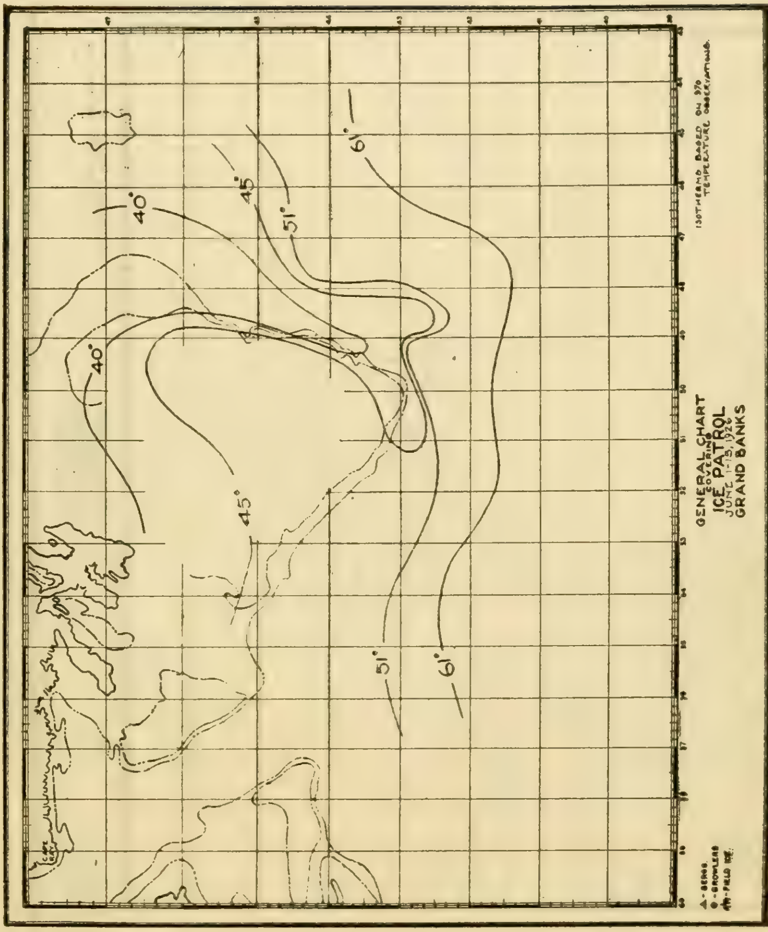


FIG. 65.—Distribution of temperature on the surface, June 1 to 15

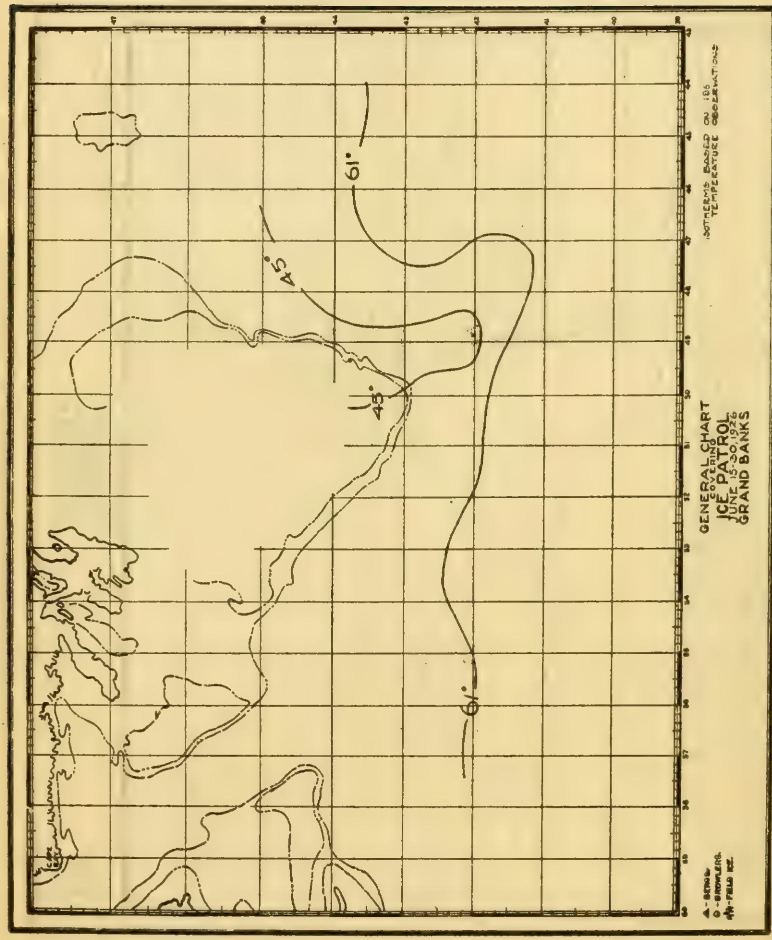
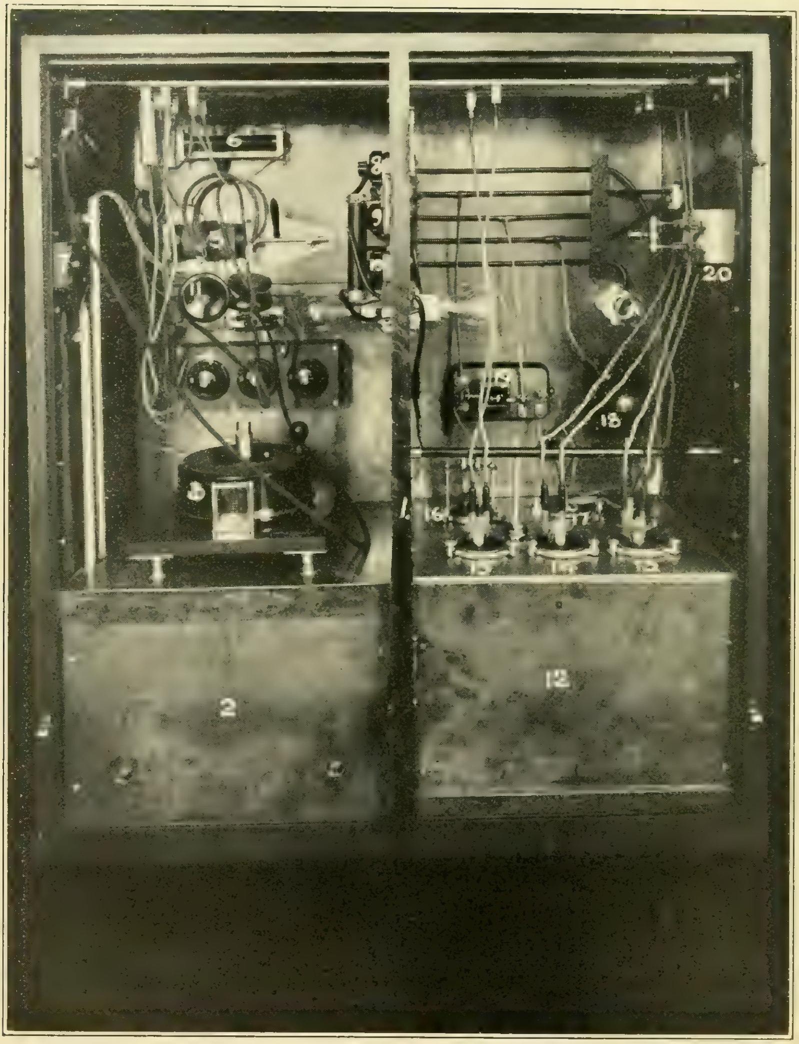


Fig. 66.—Distribution of temperature on the surface, June 15 to 30



THE ELECTRIC SALINITY TESTER

1. Wooden partition dividing cabinet; all walls copper shielded. 2. Chamber containing microphone hummer. 3. Slide wire. 4. Resistance Q. 5. Mutual inductance. 6. Slider. 7. Push-button switch connection to the measuring circuit. 8. Snap switch for extra heater circuit. 9. Snap switch for heater in series with relay. 10. Snap switch for stirring motor. 11. Head telephone detectors. 12. Immersion tank. 13. Test cell X. 14. Test cell X. 15. Auxiliary cell Y. 16. Thermostat. 17. Heater. 18. Stirring motor. 19. Relay. 20. Throw switch for X cells 14 and 13

THE ELECTRIC SALINITY TESTER

The ice-patrol bulletins for 1924 and 1925 (Nos. 12 and 13) contain sections [1,2] devoted to the description and method of operation of the electric apparatus for measuring the conductivity of sea water, providing a ready means of determining the salinity of water samples on shipboard. The United States Bureau of Standards constructed one such apparatus, which was first placed in successful operation the season of 1924, when some 600 odd samples of sea water were tested. Concurrent with the progressive scientific program laid down for the 1926 patrol, which attempts to follow the drift of icebergs by keeping an up-to-date current map on board the patrol ship, it became necessary to provide both ships with the apparatus, instead of one as in the past. Salinity determinations during the season of 1926 were thus made immediately after occupying each station and thus we were able to compute the dynamic value, and so to construct a current map on the spot. The new salinity tester was constructed with the cooperation of the Bureau of Standards in time for installation and calibration on board the *Tampa* before she sailed in March. The old set was placed on board the *Modoc*, and both machines, it ought to be added, are alike in detail. A total of about 537 salinity determinations were made during the season of 1926, and no difficulties were experienced with the functioning of the apparatus. A conversion table of scale readings to salinities follows, for use in the operation of these or similar sets in the future.

The scale range of the instrument readings it will be noted extends from 0 to 800. Readings higher than 800 are obtainable by continuing the graph of salinities plotted against instrument readings and checked occasionally by an actual test of a sample of known salinity within the discussed range.

A table of scale readings of the electric salinity tester with the corresponding values of salinity is shown herewith:

Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity
0	28.820	10	28.895	20	28.977	30	29.060	40	29.145
1	28.825	11	28.900	21	28.985	31	29.070	41	29.154
2	28.835	12	28.910	22	28.993	32	29.080	42	29.163
3	28.845	13	28.920	23	29.000	33	29.088	43	29.170
4	28.850	14	28.925	24	29.010	34	29.095	44	29.180
5	28.855	15	28.935	25	29.020	35	29.103	45	29.190
6	28.865	16	28.945	26	29.027	36	29.112	46	29.200
7	28.870	17	28.954	27	29.035	37	29.120	47	29.209
8	28.885	18	28.960	28	29.045	38	29.127	48	29.217
9	28.890	19	28.970	29	29.052	39	29.137	49	29.225

[1] U. S. Treas. Dept. Bull. No. 12, 1924, pp. 136–147.
[2] U. S. Treas. Dept. Bull. No. 13, 1925 ,pp. 67–69.

Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity
50	29.233	135	29.989	220	30.765	305	31.580	390	32.397
51	29.240	136	29.998	221	30.775	306	31.589	391	32.406
52	29.250	137	30.007	222	30.785	307	31.599	392	32.416
53	29.260	138	30.015	223	30.794	308	31.607	393	32.426
54	29.270	139	30.024	224	30.804	309	31.617	394	32.435
55	29.278	140	30.033	225	30.814	310	31.628	395	32.445
56	29.285	141	30.045	226	30.824	311	31.637	396	32.455
57	29.295	142	30.051	227	30.833	312	31.646	397	32.465
58	29.304	143	30.059	228	30.843	313	31.656	398	32.475
59	29.313	144	30.068	229	30.853	314	31.666	399	32.484
60	29.321	145	30.077	230	30.863	315	31.675	400	32.494
61	29.328	146	30.085	231	30.872	316	31.685	401	32.504
62	29.337	147	30.094	232	30.882	317	31.695	402	32.513
63	29.435	148	30.103	233	30.892	318	31.704	403	32.522
64	29.355	149	30.111	234	30.901	319	31.714	404	32.537
65	29.364	150	30.120	235	30.911	320	31.724	405	32.542
66	29.373	151	30.129	236	30.920	321	31.733	406	32.551
67	29.383	152	30.138	237	30,930	322	31.743	407	32.560
68	29.392	153	30.146	238	30.939	323	31.752	408	32.571
69	29.403	154	30.155	239	30.949	324	31.762	409	32.580
70	29.410	155	30.164	240	30.959	325	31.771	410	32.589
71	29.419	156	30,172	241	30.969	326	31.781	411	32.598
72	29.428	157	30.181	242	30.978	327	31.791	412	32.607
73	29.437	158	30.190	243	30.988	328	31.800	413	32.616
74	29.446	159	30.199	244	30.997	329	31.810	414	32.627
75	29.455	160	30.208	245	31.006	330	31.820	415	32.637
76	29.464	161	30.217	246	31.016	331	31.829	416	32.646
77	29.473	162	30.226	247	31.026	332	31.838	417	32.656
78	29.482	163	30.235	248	31.035	333	31.848	418	32.665
79	29.491	164	30.244	249	31.045	334	31.857	419	32.676
80	29.500	165	30.253	250	31.055	335	31.866	420	32.684
81	29.509	166	30.262	251	31.065	336	31.877	421	32.692
82	29.518	167	30.271	252	41.075	337	31.886	422	32.702
83	29.527	168	30.280	253	31,084	338	31.896	423	32.713
84	29.536	169	30.289	254	31.094	339	31.906	424	32.723
85	29.545	170	30.298	255	31.103	340	31.915	425	32.732
86	29.554	171	30.307	256	31.113	341	31.925	426	32.742
87	29.563	172	30.317	257	31.122	342	31.935	427	32.752
88	29.572	173	30.326	258	31.132	343	31.945	428	32.762
89	29.581	174	30.336	259	31.142	344	31.955	429	32.772
90	29.590	175	30.345	260	31.152	345	31.964	430	32.780
91	29.599	176	30.354	261	31.162	346	31.974	431	32.789
92	29.608	177	30.363	262	31.172	347	31.984	432	32.799
93	29.617	178	30.372	263	31.181	348	31.993	433	32.808
94	29.626	179	30.382	264	31.191	349	32.003	434	32.819
95	29.635	180	30.392	265	31.200	350	32.013	435	32.828
96	29.644	181	30.401	266	31.209	351	32.022	436	32.837
97	29.653	182	30.410	267	31.219	352	32.032	437	32.847
98	29.662	183	30.419	268	31.228	353	32.041	438	32.857
99	29.687	184	30.428	269	31.238	354	32.051	439	32.867
100	29.680	185	30.437	270	31.248	355	32.061	440	32.876
101	29.689	186	30.446	271	31.258	356	32.071	441	32.886
102	29.698	187	30.456	272	31.267	357	32.080	442	32,896
103	29.706	188	30.465	273	31.277	358	32.090	443	32.905
104	29.715	189	30.475	274	31.287	359	32.100	444	32.916
105	29.724	190	30.485	275	31.296	360	32.110	445	32.925
106	29.732	191	30.494	276	31.306	361	32.119	446	32.934
107	29.741	192	30.503	277	31.315	362	32.129	447	32.943
108	29.750	193	30.512	278	31.325	363	32.138	448	32.953
109	29.759	194	30.521	279	31.335	364	32.148	449	32.963
110	29.767	195	30.530	280	31.345	365	32.157	450	32.972
111	29.775	196	30.539	281	31.354	366	32.166	451	32.982
112	29.784	197	30.548	282	31.364	367	32.176	452	32.992
113	29.793	198	30.557	283	31.373	368	32.187	453	33.001
114	29.810	199	30.566	284	31.383	369	32.197	454	33.011
115	29.810	200	30.575	285	31.392	370	32.206	455	33.021
116	29.819	201	30.585	286	31.401	371	32.215	456	33.030
117	29.828	202	30.594	287	31.411	372	32.225	457	33.040
118	29.837	203	30.604	288	31.420	373	32.235	458	33.050
119	29.845	204	30.613	289	31.430	374	32.245	459	33.061
120	29.855	205	30.622	290	31.440	375	32.255	460	33.069
121	29.863	206	30.632	291	31.449	376	32.264	461	33.077
122	29.871	207	30.641	292	31.458	377	32.274	462	33.087
123	29.880	208	30.650	293	31.467	378	32.283	463	33.098
124	29.887	209	30.660	294	31.476	379	32.293	464	33.107
125	29.895	210	30.670	295	31.485	380	32.302	465	33.117
126	29.913	211	30.679	296	31.494	381	32.311	466	33.127
127	29.921	212	30.689	297	31.503	382	32.320	467	33.137
128	29.929	213	30.698	298	31.512	383	32.330	468	33.147
129	29.937	214	30.708	299	31.521	384	32.340	469	33.156
130	29.945	215	30.717	300	31.530	385	32.349	470	33.166
131	29.954	216	30.721	301	31.540	386	32.359	471	33.176
132	29.963	217	30.736	302	31.551	387	32.368	472	33.186
133	29.972	218	30.746	303	31.562	388	32.378	473	33.196
134	29.980	219	30.755	304	31.571	389	32.388	474	33.206

Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity	Reading	Salinity
475	33.215	537	33.829	599	34.460	661	35.115	723	35.777
476	33.225	538	33.840	600	34.470	662	35.126	724	35.789
477	33.235	539	33.850	601	34.480	663	35.137	725	35.799
478	33.245	540	33.860	602	34.490	664	35.147	726	35.810
479	33.255	541	33.870	603	34.500	665	35.158	727	35.821
480	33.265	542	33.880	604	34.511	666	35.169	728	35.833
481	33.275	543	33.890	605	34.521	667	35.180	729	35.844
482	33.285	544	33.900	606	34.531	668	35.190	730	35.854
483	33.295	545	33.910	607	34.542	669	35.201	731	35.864
484	33.305	546	33.920	608	34.553	670	35.211	732	35.875
485	33.315	547	33.930	609	34.564	671	35.221	733	35.886
486	33.325	548	33.941	610	34.575	672	35.232	734	35.897
487	33.335	549	33.952	611	34.583	673	35.242	735	35.909
488	33.345	550	33.962	612	34.593	674	35.252	736	35.920
489	33.355	551	33.972	613	34.606	675	35.263	737	35.932
490	33.365	552	33.982	614	34.616	676	35.273	738	35.944
491	33.374	553	33.992	615	34.626	677	35.284	739	35.955
492	33.384	554	34.002	616	34.636	678	35.295	740	35.965
493	33.393	555	34.012	617	34.647	679	35.306	741	35.975
494	33.403	556	34.022	618	34.659	680	35.316	742	35.985
495	33.413	557	34.031	619	34.670	681	35.326	743	35.997
496	33.422	558	34.042	620	34.680	682	35.336	744	36.009
497	33.432	559	34.052	621	34.690	683	35.347	745	36.019
498	33.442	560	34.062	622	34.700	684	35.359	746	36.028
499	33.451	561	34.070	623	34.711	685	35.370	747	36.040
500	33.461	562	34.081	624	34.722	686	35.380	748	36.055
501	33.470	563	34.091	625	34.733	687	35.391	749	36.070
502	33.480	564	34.102	626	34.743	688	35.401	750	36.080
503	33.490	565	34.112	627	34.754	689	35.412	751	36.090
504	33.500	566	34.122	628	34.765	690	35.424	752	36.102
505	33.509	567	34.132	629	34.775	691	35.434	753	36.115
506	33.519	568	34.143	630	34.785	692	35.444	754	36.129
507	33.530	569	34.153	631	34.796	693	35.455	755	36.140
508	33.540	570	34.163	632	34.806	694	35.466	756	36.153
509	33.550	571	34.173	633	34.816	695	35.477	757	36.166
510	33.559	572	34.183	634	34.827	696	35.488	758	36.177
511	33.568	573	34.193	635	34.837	697	35.499	759	36.192
512	33.577	574	34.203	636	34.848	698	35.510	760	36.204
513	33.587	575	34.214	637	34.859	699	35.521	761	36.216
514	33.597	576	34.224	638	34.870	700	35.532	762	36.228
515	33.607	577	34.234	639	34.880	701	35.542	763	36.243
516	33.617	578	34.244	640	34.890	702	35.553	764	36.256
517	33.626	579	34.254	641	34.901	703	35.564	765	36.271
518	33.637	580	34.264	642	34.912	704	35.575	766	36.285
519	33.647	581	34.273	643	34.922	705	35.586	767	36.297
520	33.657	582	34.284	644	34.933	706	35.596	768	36.314
521	33.666	583	34.294	645	34.943	707	35.607	769	36.328
522	33.676	584	34.305	646	34.954	708	35.617	770	36.345
523	33.686	585	34.315	647	34.965	709	35.629	771	36.359
524	33.697	586	34.325	648	34.976	710	35.640	772	36.370
525	33.707	587	34.335	649	34.987	711	35.650	773	36.386
526	33.717	588	34.346	650	34.998	712	35.661	774	36.403
527	33.727	589	34.356	651	35.007	713	35.671	775	36.425
528	33.738	590	34.367	652	35.017	714	35.682	776	36.438
529	33.748	591	34.377	653	35.028	715	35.691	777	36.457
530	33.758	592	34.387	654	35.040	716	35.702	778	36.477
531	33.768	593	34.398	655	35.051	717	35.713	779	36.502
532	33.778	594	34.409	656	35.061	718	35.724	800	36.500
533	33.789	595	34.419	657	35.071	719	35.735		
534	33.799	596	34.430	658	35.085	720	35.746		
535	33.809	597	34.439	659	35.095	721	35.755		
536	33.819	598	34.449	660	35.105	722	35.766		

TREASURY DEPARTMENT - UNITED STATES COAST GUARD

BULLETIN No. 16

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN - [SEASON of 1927]

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UNITED STATES COAST GUARD

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INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE

IN THE

NORTH ATLANTIC OCEAN

Season of 1927

UNITED STATES
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WASHINGTON
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PLATE I.—ARCTIC FIELD ICE WHICH HAS ITS SOURCE NORTHWARD IN HUDSON STRAIT AND BAFFIN BAY. IT REACHES ITS MAXIMUM IN THE GRAND BANKS REGION DURING MARCH AND APRIL, AND IS RARELY FOUND SOUTH OF BELLE ISLE AFTER THE MONTH OF MAY. THIS PARTICULAR FIELD EAST WAS SIGHTED BY THE "TAMPA," MAY 6, ABOUT 120 MILES OF ST. JOHNS, NEWFOUNDLAND

PLATE II.—A GREAT NUMBER OF BERGS THAT WERE SIGHTED BY THE "TAMPA," MAY 6, 1927. MORE THAN 70 WERE IN SIGHT FROM THE BRIDGE AT ONE TIME

THE INTERNATIONAL ICE PATROL

1927

The international ice patrol for the season of 1927 was carried on by the United States Coast Guard cutters *Modoc* and *Tampa;* the former was in command of Commander W. H. Munter and the latter was in command of Commander Thomas M. Molloy. The Coast Guard cutter *Mojave*, with headquarters at Boston, Mass., was designated the standby vessel. While on patrol, the *Tampa* and *Modoc* based temporarily at Halifax, Nova Scotia, the two vessels making alternate cruises of about 15 days in the ice regions, and the 15 days being exclusive of the time occupied in going to and from the base. Commander Munter was the commander of the ice patrol, and Lieutenant Commander Edward H. Smith was detailed to assist and advise the commanding officers while they were in the ice regions and to compile data and information for the annual report.

The duties and scientific work carried on by the ice patrol were, in general, similar to the practice of the previous season. The primary object of the patrol was to locate by scouting, and radio information, the icebergs and ice fields nearest to, and menacing, the North Atlantic lane routes, and to determine the southerly, easterly, and westerly limits of the ice and to keep in touch with it as it moved southward. Radio broadcast were sent out four times daily giving the whereabouts of this ice and particularly that which was in the immediate vicinity of the North Atlantic lane routes, and ice information was furnished by radio at any time to any ship with which the patrol vessel could communicate. In order that an intelligent service of the highest order be rendered to shipping, an oceanographic program was carried out to afford the vessel on patrol with a practical, up-to-date current map of the critical, infested ice area under surveillance, and scientific studies and observations made bearing upon ice conditions and ice movements. The oceanographic and scientific work being supportive, and secondary in importance, was so arranged that it would not hamper the ice patrol in its primary function of ice scouting.

The *Tampa* inaugurated the patrol on March 22 and from that date until June 25 there was either that vessel or the *Modoc* continuously on guard in the ice regions.

Beside the ice-patrol service, the safety of shipping is further guaranteed by mutually agreed upon steamship tracks past the ice regions, prescribed by the North Atlantic track agreement. They

are designated by letters, A, B, C, D, E, and F. Tracks A, B, C, and D refer to routes between the United States and Europe, and they all run near, or south of, the Tail of the Grand Banks. Tracks C are known as winter-time courses, and they are in force from the 1st of September to the 1st of February, when the United States-Europe tracks are shifted southward to letter B, where in turn they remain during a normal ice season until September 1. If ice, however, drifts far south during the danger season it is customary, upon recommendation from the International Ice Patrol, to shift tracks B to tracks A, "extra-southerly" for a month or two. The dates of shifting are subject to changes depending mainly upon ice conditions of the particular year.

Tracks E, F (Cape Race track), and Belle Isle tracks refer to routes between Canada and Europe. Tracks E are in force normally from April 11 to May 15. Tracks F are in force from May 15 till opening of the Strait of Belle Isle, about July 1, and these latter continue in effect until the closing of navigation on the Gulf of St. Lawrence.

It is clearly seen from the foregoing that prior to April 11 all prescribed steamship tracks cross the ice regions near or south of the Tail of the Grand Banks, but after that date the Canadian-European routes separate from those of the United States-Europe, so that during the season when bergs menace navigation in greatest numbers there are two paths of ocean travel separated by a distance of about 400 miles. It ought to be mentioned that since the ice patrol was originally established the volume of traffic on the Canada-Europe routes (those are the ones that cross the ice regions during the ice-berg season) has increased many fold.

CRUISE REPORTS

THE FIRST CRUISE, "TAMPA," MARCH 22 TO APRIL 9, 1927

In accordance with headquarters telegram of March 19, 1927, the *Tampa* sailed at 1.41 in the afternoon of March 22 for the Grand Banks. During the second day at sea a message was received from the United States Hydrographic Office, Washington, stating that trans-Atlantic tracks "B" would remain in force until further notice. It took us an unusually long time—six days—this year to make the passage to the ice regions, and this slow progress was due to the presence of an area of high pressure located over Newfoundland. Our track situated on the southern side of this wind system gave us head winds the entire passage. On the 28th we sent messages to all adjacent radio stations requesting their cooperation and informing them that we were inaugurating the ice-patrol service for 1927. The routine broadcast was dispatched to all ships and also the evening report to the Hydrographic Office, Washington.

A search for ice was instituted the morning of the 29th and also on the 30th. Somewhat north of the forty-third parallel along the eastern slope of the Grand Banks we sighted a total of three small bergs and one growler. The *Tampa* remained near this ice and drifting with it to the southward during the remaining two days of the month. From April 1 to 6 the time was spent searching for ice around the Tail of the Bank and along the eastern slope, or drifting near small bergs or growlers. The weather was exceptionally good during these days; for example, on March 26 there was not a cloud in the sky the entire day and the sea was very calm, two conditions truly remarkable for this time of the season.

We planned during the last few days of the cruise to begin a current survey along the eastern side of the Bank and carry the observations to the westward, and when the relief ship was met, giving her the remaining half of the oceanographic work to perform. This program was carried out and we met the *Modoc* about 150 miles west of the Tail of the Grand Banks on the eighth day of the month where the relief was effected and the *Tampa* stood toward Halifax.

The weather this cruise was noticeably fair and much better by far than that we encountered during the early part of the patrol last year. There were a few intervals of low visibility but no fog. During the cruise we received a total of 630 reports from passing vessels on the subject of their surface water temperatures; three vessels

were supplied with special ice information; two with track information; 125 ice reports were received. A total of six small icebergs was sighted.

THE SECOND CRUISE, "MODOC," APRIL 9 TO 24, 1927

The 9th and 10th instants were sufficient to complete the oceanographic survey, and when the *Modoc* had arrived off the Tail of the Banks the program was then turned to scouting along the eastern side of the Bank for ice. About 4 o'clock the afternoon of the 11th a berg was sighted in a position which proved to be 20 miles south of the Bank and we stood by it for the remainder of the day. During the next two days this berg drifted to the westward and then northwestward and finally into shoal water on the Bank itself. When we left it, on the 15th, it had not changed position for two consecutive days, and this, coupled with the fact that it was very much reduced in size, caused us to leave and begin searching northward for other menaces.

About 3 o'clock in the afternoon of the 16th the *Modoc* sighted the largest berg that had been seen this season, and while lying near this ice we received our first intimation that the warm, off-shore, countercurrent was pressing in toward the Bank this year unusually far. In fact, this large berg beside which we had stopped, it was plain to see, was in this countercurrent although its position was barely 40 miles outside the 100-fathom curve. It was extraordinarily calm that evening and the demarkation between the two currents could easily be seen stretched about 2 miles to the westward of us, and running in a direction more or less parallel to the trend of the slope. Easter Sunday the wind increased to gale force and in the storm we lost sight of our quarry but the fact that this ice was known to be in the warm countercurrent was more or less reassuring of a rapid disintegration. The large berg was reported for the last time on the 20th about 30 miles to the northeastward of our position surrounded by several growlers, showing that it was breaking up rapidly.

Now the cruise was drawing near its close, so we followed a program similar to the one used on the *Tampa*—taking oceanographic stations on the slope and working around to the westward. The *Tampa* was met on the morning of the 24th of April and the patrol duty turned over to her.

During this cruise we received several reports of field ice and icebergs to the northward. The field ice on the northern edge of the Bank was, of course, Arctic in origin, but the field which extended southward to a point 25 miles north of Sable Island came from the St. Lawrence. There were very few ships on the tracks which led across the northern part of the Banks. The initial vessel bound for the Gulf this year is believed to have been the steamship *Bolingbroke*, which

reported her position on track "E" April 19. The same day we were informed that the Canadian ice patrol ship *Mikula* was now on her station near Cabot Straits.

The outstanding feature of the cruise was the inshore distribution of the ice as it was carried southward. Where it is usually transported in the heart of the current along the 100-fathom contour of the continental edge, this year it was moving southward 15 to 25 miles inshore of that zone. Such a condition is attributed to the warm Atlantic waters pressed in against the continental slope combined with an abnormal prevalence of easterly and northeasterly winds. We received 840 water temperature reports, 89 ice reports, sighted 7 icebergs, gave 13 ships special ice information, and requested 27 others to acknowledge for the evening broadcast, as it was observed that their courses were taking them dangerously close to ice.

THE THIRD CRUISE, "TAMPA," APRIL 24 TO MAY 8, 1927

The current survey begun on the *Modoc* was completed in two days, and the same evening, the 25th, a report was received regarding an iceberg about 100 miles due west of the Tail, in a position which we had passed over in the morning. This ice was missed probably because of the poor visibility, it being hazy and foggy all the previous day. We headed toward the reported locality, of course, and fortunately sighted the berg dead ahead at 7 o'clock on the morning of the 26th. It was hard to account for this ice having followed the usual path toward the Tail, and the only conclusion tenable was that it must have drifted diagonally across the Bank, southwestward. Such an opinion was supported, furthermore, by the fact that on the 21st, five days previous, the *Modoc* had sighted a berg about 40 miles to the northeast of this position, to which the berg we were standing by bore a close resemblance. We drifted with this ice for the next three days and during that time it constantly melted and finally completely broke up, but did not move far away from the spot at which it was originally sighted. More than passing interest attaches to this ice because it happened to be the last berg for the season of 1927 to drift so far southward and, moreover, proved to be, out of all the bergs for the season, the one which drifted nearest to the westbound steamship tracks "B;" a distance of 70 miles. (See fig. 28.)

Fog and storms interrupted the ice-searching program for the next few days and it was not until the 3d of May that the *Tampa*, at 13 knots speed, resumed scouting along the eastern side of the Bank. There followed several days of clear weather during which time we pushed home the search and covered the cold current along the entire eastern side of the Bank, thence westward to the coast of Newfoundland. May 6, when about 100 miles east of St. Johns, Newfoundland,

the *Tampa* sighted a great quantity of ice; approximately 100 bergs and several ice fields during the day (see Pl. II). This is the largest number of bergs, according to records, ever sighted at one time by the patrol ship around the Grand Bank.

The *Modoc* was met on the 8th of May near Cape Race and the patrol duty turned over to her. There were 1,040 sea-water temperature reports received, 82 reports of ice, about 120 bergs sighted, 6 steamships given special ice information upon request, and 23 vessels were asked to acknowledge for our evening ice broadcasts.

THE FOURTH CRUISE, "MODOC," MAY 8 TO 23, 1927

The *Modoc* proceeded to the eastern side of the Grand Bank, arriving there on the 10th of May, and after locating the southernmost bergs on the slope just north of the forty-sixth parallel, prepared to take a line of oceanographic stations off to the eastward, the beginning of a current survey. We were handicapped in this work on account of the drum of the new oceanographic hoist the flange head of which broke in two after taking the second station. The second hoist was quickly installed, however, by the crew working most all of that night, and in the morning we were ready to go ahead again.

A message was received from headquarters early the morning of the 11th requesting the *Modoc* to keep a bright lookout for an airplane on its nonstop flight from New York to Paris, the *Modoc* taking a position about 60 miles due south of the Tail in the reported line of flight. As the time of flying was postponed on account of bad weather conditions prevailing in the North Atlantic, we took advantage of the delay to continue with the current survey, running a line of stations normal to the slope and southward to this forementioned position, thus the time was spent from May 11 to the 20th. During this period, by the way, almost continuous south winds and fog prevailed. No ice was sighted and there were very few reports from ships regarding this subject. The few bergs that were observed were distributed on the northern part of the Bank; some of the same ice which we had previously sighted May 6 on the *Tampa*.

The last few days of the cruise clear weather set in and the patrol ship was cruised northward along the eastern slope of the Bank, searching for ice. Only one berg was sighted and that on the last day of the cruise, it being found just north of the forty-sixth parallel in the shoal water inside the 50-fathom curve.

Following is a summary of the ice patrol work during the cruise: Sea-water temperatures received, 1,100; ice reports received, 42; vessels requested to acknowledge for our broadcasts, 10; special ice information given, 9; and bergs sighted, 1.

THE FIFTH CRUISE, "TAMPA," MAY 24 TO JUNE 8, 1927

After relieving the *Modoc*, about 200 miles east of Cape Race, we stood to the northward and began searching at daylight along the eastern slope of the Bank. Visibility became poor at noontime on account of snow squalls, but before it shut in thick a large berg was seen not far away beside which we stopped for the night. It was estimated to-day that there was a total of 40 bergs and 60 growlers scattered along both sides of the Cape Race track from latitude 48° 00′, longitude 48° 30′, and all the way to Cape Race. The ice was especially concentrated in the vicinity of latitude 47° 30′, and longitude 50° 20′.

The next day, May 25, we experienced one of the most severe gales of the season and there was little else to be done but drift near the berg of yesterday. When the gale abated we searched in the vicinity and located a total of six bergs all strung along out the northeastern slope of the Bank and drifting southward at the rate of 1.2 knots per hour.

At this time we began an oceanographic survey which extended outhward along the Bank and had for its purpose the mapping of the position of the two currents because it was being quite important at this time to have on board the patrol ship information regarding the probable path which the group of icebergs mentioned above would take. We were successful in this plan and the behavior of the ice followed closely to the position of the current as calculated. (See fig. 46, p. 86.) One iceberg of this group which succeeded in hugging close to the edge of the Bank, and thereby drifting south the farthest, was sighted on the 1st of June in latitude 44° 55′, longitude 48° 25′.

June 2 was foggy but it cleared the 3d, and remained good visibility the 4th and 5th, permitting the patrol vessel to make a fairly thorough search of the eastern and northern slopes of the Grand Bank. Many bergs were found in the locality which the *Tampa*, a month prior to this date, sighted 70 bergs at one time from the bridge, but now the number had been very much reduced due to melting and disintegration.

One of the most interesting events of the cruise occurred early the morning of the 6th when we intercepted a message from Cape Race radio station stating that a French fishing vessel had stranded about 3 miles west of the station. The *Tampa* headed toward Cape Race, 129 miles away, and full speed was ordered in the hopes that there would be an opportunity to save this vessel. An untimely arrival of a low-pressure area north of Newfoundland brought a southerly gale this same day, and at the same time a choppy sea made up, which soon made short work of this unfortunate vessel stranded on a rocky, lee shore. We were forced to give up the attempt of rescue and made

the best use possible of the remaining time of this cruise to locate ice in the vicinity of Cape Race. The patrol work during the cruise consisted of receiving 1,100 water-temperature reports, 82 ice reports, 18 vessels were asked to acknowledge for evening broadcasts, 14 special ice-information reports were given, and a total of about 40 bergs sighted.

THE SIXTH CRUISE, "MODOC," JUNE 8 TO 23, 1927

Our first task was to search eastward along the northern slope of the Bank about 15 miles north of the track made by the *Tampa* on her course to the westward a few days ago. The search was handicapped to a great extent by patches of fog and low visibility, but, nevertheless, we sighted about 10 bergs and several growlers while on this work, which was concluded on the 10th instant. Advantage was also taken of several steamers on courses more or less paralleling ours to the north and south, to estimate that there was a total of 68 bergs this date south of the forty-eighth parallel.

The final oceanographic survey for 1927 was begun on June 10 and carried out, but for a single interruption, the remainder of the time which the *Modoc* had the patrol duty. During the course of nine days we covered the largest area which had ever been accomplished on patrol, namely, from the forty-eighth parallel south to the Tail, and from the Grand Bank eastward to Flemish Cap. This survey was timely and proved to be of inestimable value toward forming an accurate opinion, and resulting recommendation, for the discontinuance of ice patrol. This is an example of the value attached to scientific investigations of the currents around the Grand Banks. Never before have patrol officials been so well informed and been able to express such an intelligent prediction as to the status of the ice menace as they were at the close of the season of 1927.

On the 13th instant the *Modoc's* current survey was interrupted for two days by an urgent call for medical assistance from the steamer *Conness Peak*, then well out in mid-Atlantic. The *Modoc* on this mission, without doubt, was able to save the life of the second officer who had received serious injuries as the result of a fall.

June 24 we met the *Tampa* about 150 miles west of the Tail of the Bank, and, after a conference between the two ships, the commander, international ice patrol, forwarded a dispatch to headquarters which contained a résumé of the principle features of the ice season, the survey of the present situation, and his recommendation for the discontinuance of the patrol.

The following is a summary of the work performed during the sixth cruise: 848 water-temperature reports received, 77 ice reports received, 13 vessels were asked to acknowledge for the evening broadcasts, 10 ships were given special ice information, and 36 icebergs sighted.

THE SEVENTH CRUISE, "TAMPA," JUNE 24 TO 25, 1927

We began work on a survey of the currents around the Tail of the Bank and along the southwest slope, but this work was abandoned upon the receipt of orders from Washington to discontinue ice patrol and return to home stations. Messages of thanks for cooperation were sent to all neighboring radio stations as well as to the steamships which happened to be in the ice regions.

RADIO COMMUNICATIONS

One of the most important features of the ice patrol work is an efficient and consistent performance of radio communication; in fact, the success of the patrol lies to a great extent in correctly accumulating and disseminating the ice and obstruction information. The ice area, moreover, which is kept under surveillance by the patrol ship, is greatly enlarged by the information received over the radio from ships scattered throughout the entire ice regions. The operations of 1927, as in past years, revealed excellent cooperation on the part of the merchant vessels and the shore stations; a spirit which is highly gratifying to the patrol. We desire also to add that the Canadian direction-finding stations, Cape Race commercial radio station, and bordering United States naval radio stations have done all possible to facilitate the patrol radio communications.

We are impressed, when making a survey of the radio work of 1927, with the fact that schedules between the United States naval radio stations and the patrol ship were maintained more consistently than ever before. This condition is attributed, first, to the higher power used this year by naval stations, and, second, to the personal cooperation shown by the individual operators both ashore and afloat. In previous years, too, ship-to-shore communication has often been interrupted by summer-time static conditions, but this difficulty in 1927 was seldom encountered, and then for short periods only.

The radio equipment carried on board the patrol vessels was practically the same as that used in 1926. (See Bulletin No. 15.) The high-frequency experimental receiver was replaced by a new type called the "R.G." high-frequency receiver, the latter being a later model, better constructed, possessing a wider range of frequencies, and also being more sensitive than the older receiver to weak signals. The R.G. receiver proved itself far superior both in ease of control and signal amplification than any of the former types of apparatus. The XA 500-watt high-frequency transmitter was the same as that used last year with the exception of several alterations made at the Navy experimental laboratory, Bellevue, Md., during the winter of 1926–27. Improvements included easier adjustment on specified frequencies, and installation of a plate overload relay, in order that damage would not result because of sudden rise of plate voltage. The only trouble experienced with any of the apparatus during the patrol occurred on board the *Tampa*, where a variable ground developed in the high-voltage leads of the 2,500-volt main radio motor

generator. Both the T–2 2-kilowatt tube transmitter and the XA 500-watt high-frequency set, in consequence, were out of commission for three days until repairs were completed. The *Tampa*, fortunately, carried spare generator parts on board for just such an emergency. The trouble caused no delay, however, in the reception of ship reports, because a separate power supply is used in connection with the spark transmitter for the purpose of ship-to-ship communication.

The radio electrician in charge of ice patrol communications, and detailed to remain continuously at sea, was taken seriously ill during the first part of the ice season, and it was necessary for him to return to Boston for treatment. The vacancy thus created was filled by a radio man, first class, assigned from the personnel of the *Tampa*, who transferred from ship to ship for the remainder of the patrol.

The amount of ice patrol traffic handled by radio is always interesting and indicative of the importance of this work to the success of the patrol. There were approximately 5,548 reports received from passing steamers concerning their position, course, speed, and sea-water temperatures. A total of 380 official messages were transmitted to Washington, and 84 were received. It is estimated that a total of 274,407 words were handled during the season of 1927 (see p. 15).

There is appended herewith a schedule giving the times at which messages were received and sent by the patrol vessel. This schedule was adopted after several preliminary tests in 1926, and, as outlined here, was found quite satisfactory for the season of 1927.

(All times are seventy-fifth meridian)

0600. Ice broadcast (spark); call on 600 meters, then send twice on 706 meters with a 2-minute interval.

0700. Ice broadcast (continuous wave); call on 600 meters, then send twice on 1,713 meters with a 2-minute interval.

0730. Clear all ship-to-shore traffic with Washington (NAA). Ice patrol using 410 kilocycles.

0800. Clear all ship-to-shore traffic with Bar Harbor (NBD) in case the 0730 schedule fails. Ice patrol using 1,713 meters.

0915. Copy Cape Race weather and obstruction broadcast.

1030. Copy Arlington weather broadcast.

1200. Copy time signals and ice patrol traffic from Arlington (NAA).

1800. Ice broadcast (spark); call on 600 meters, then send twice on 706 meters with a 2-minute interval.

1900. Ice broadcast (continuous wave); call on 600 meters, then send twice on 1,713 meters with a 2-minute interval.

1930. Clear all ship-to-shore traffic with Washington (NAA) on high frequency.

2000. Clear all ship-to-shore traffic with Bar Harbor (NBD) in case the 1930 schedule fails. Ice patrol using 1,713 meters.

2115. Copy Cape Race weather broadcast.

2200. Copy time signals and ice patrol traffic from Arlington (NAA).

2230. Copy weather broadcast from Arlington (NAA).

SUMMARY REPORT OF COMMANDER INTERNATIONAL ICE PATROL

The ice patrol was inaugurated March 22, when the *Tampa* sailed from Boston. The *Modoc* left Boston in sufficient time to relieve the *Tampa* after she had been on duty for 15 days. These two Coast Guard cutters then alternated on duty throughout the remainder of the season, one of the vessels being continuously on guard in the ice regions. This work required a total of seven cruises, and Halifax, Nova Scotia, was made the port of call at which fuel and supplies were obtained. The patrol service was discontinued on June 25 when a dispatch from headquarters directed the vessels to return to their respective stations. The total period during which the vessels were on guard was 95 days—3 days short of the time in 1926.

The patrol work has been for some few years regarded as having two general features: First, and of primary importance, is the actual search carried on by the patrol; the collecting of all the ice reports from passing vessels; and the dissemination of this information four times daily. Second only to the foregoing is the scientific work which in late years has centered on frequent surveys of the currents which transport the ice about to various menacing positions.

We wish in referring to the practicable work this year to briefly summarize the general distribution of ice and its behavior. A discussion of the subject is carried in greater detail under the section devoted to ice observation (p. 52), to which the reader's attention is invited. As early as March 11, a prediction was made in accordance with an iceberg forecasting equation (see Bull. No. 15, p. 48) that 396 bergs would drift south of Newfoundland for the season of 1927. It developed actually that there was slightly more ice during the spring of 1927 than occurs in a normal year about 380, and this agreement between fact and prediction lends added confidence to such a method of iceberg forecasting for future years. Although the number of bergs south of Newfoundland (below the forty-eighth parallel), was slightly above the average, the amount of ice around the Tail of the Bank and near the United States-Europe steamship tracks was remarkably deficient. The interference in the normal distribution is attributed to two factors, (1) the predominance of northeasterly winds during the early part of the season and, (2) the unusual inshore invasion of warm counter oceanic currents. The discussion of these features in considerable detail will be found under

sections devoted to weather and to oceanography. There were approximately 365 bergs south of Newfoundland during the four months March to June but there was the astonishingly meager number of only eight bergs south of the forty-fifth parallel during this same period. The greatest number of bergs around the Tail at any time occurred the first week in April when there were four small ones there, and the patrol kept these under surveillance until they finally melted. The last berg to appear off the Tail did so April 28, and thereafter these waters were clear of ice during May and June. In fact with the exception of a small berg which drifted 10 miles south of the forty-fourth parallel on June 8, there was no ice south of the forty-fifth parallel after April 30.

The fact that the total number of bergs was slightly above normal, and that the waters south of the forty-fifth parallel remained so free of ice, naturally concentrated the bergs on the northern part of the Bank where as many as 100 to 150 accumulated the first week in June. They disintegrated quite rapidly, however, because when the patrol vessel left, June 25, it was estimated that there were few more than 15 bergs south of Newfoundland.

The weather during the ice season of 1927 was in general very good. Both the *Tampa* and the *Modoc* on their first cruises experienced unusually fine weather at a time in early season when cyclonic disturbances are often numerous and gradients are correspondingly steep. It was recalled that in the early season of 1926 the vessels encountered continual gales for the first month of the patrol. The second feature was the change from wintertime to summertime conditions with attending southerly winds, an event which was first noticed May 11, contemporary with the first long spell of fog and low visibility. The usual stagnation in the movement of low-pressure and high-pressure areas, and the flattening out of gradients, was not so apparent this season as it has been in some years. Several times during the month of June, for example, well developed "highs" and "lows" moved across the ice regions with unseasonable velocity.

Scientific work this year was carried on under the supervision of Lieutenant Commander Smith, who followed the same general policies that were instituted by the ice patrol board in 1926. A discussion of the weather, the distribution of the ice, and the scheme of oceanic circulation that prevailed in the ice regions, is carried under the respective sections devoted to weather, ice observation, and oceanography. The absence of ice near the steamship lanes in 1927 afforded opportunity for more current observations than ever before, and consequently, the patrol ship was able to foresee more clearly than ever in 1927, the developments in the ice situation. Attention is particularly invited to the current map covering the last few weeks

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of the patrol (see fig. 50, p. 90), during which time the waters of the entire eastern side of the Grand Banks were mapped. This timely information enabled the patrol to forward to Washington officials an intelligent and accurate recommendation regarding the safety of the trans-Atlantic tracks. The drift of the ice and the stream lines of the currents, as calculated from the station data, agreed very closely. The methods employed in determining the direction and velocity of the currents around the Grand Bank, which are described in Bulletin No. 14, 1925, appear very feasible and the results in 1927 certainly threw an intelligent light upon the probable movements of the ice, a subject which naturally is of inestimable value to those in charge of the patrol work.

The patrol ships had on board practically the same outfits as carried in 1926 with the exception of a larger number of spare oceanographic instruments. The installation of new electric hoists for lowering and hoisting the water bottles was a great improvement which shortened the time spent at stations by almost one-half. The policy begun in 1926 of carrying out a survey of the bottom contour whenever opportunity afforded was continued by the *Tampa* in 1927, and about 435 sonic soundings were obtained in this manner. The sonic apparatus is also of invaluable assistance in locating the position of the patrol ships, and the ice sighted, during the protracted periods of cloudy and foggy weather around the Banks. The radio apparatus functioned quite satisfactorily this year with the exception of three days when the *Tampa's* main motor radio generator developed a ground. The trouble was located, however, and by working night and day the patrol ship was soon back on radio schedules. The breakdown, it should be added, did not affect the set which is used to communicate with passing vessels, as the spark set is on a separate generating circuit.

About 450 steamships are known to have taken advantage of the service provided by the ice patrol this year, and no doubt there were many more, that also listened in for the daily broadcasts. We made a few inquiries as to how far the ice patrol reports were picked up, and what the general policy was among the steamers regarding listening in for the ice broadcasts. The replies indicated that radio contact with the patrol was usually made at a distance of about 450 miles east and west of the Grand Banks; also that the commercial radio operators were given standing orders to copy the broadcasts at all times when within this range, giving the messages priority over all other traffic. The following list is submitted in order that the reader may obtain an idea of the service which is being furnished the ships of many nations. The masters of these vessels have been thanked, by letter, by the chairman of the ice patrol board.

Belgian	4	Dutch	30	Italian	17	Spanish	3
British	150	French	7	Japanese	3	Swedish	25
Canadian	36	German	12	Norwegian	32	United States	104
Danish	17	Greek	2	Portuguese	1		

A summary of the work performed, the dissemination of the information, and other miscellaneous business handled by the patrol for 1927 follows:

Washington official messages	424
Daily routine broadcasts	380
Special broadcasts (during fog)	8
Ice information to certain vessels, special	91
Special ice information requested	55
Position reports requested	6
Track information requested	2
Weather reports received	464
Water temperature reports received	5, 548
Ice reports received:	
Steamships	380
Cape Race radio station	107
Medical treatment by radio	3
Violation of steamship tracks reported	1
Radio compass bearings received	291
Words handled by radio	274, 407

As in previous years, the cooperation received from passing ships was generous and indicative of a sincere appreciation of the service which is being financially supported by international contribution. The commander of the ice patrol takes this opportunity to thank all those who assisted in making this past season's work so successful.

TABLE OF ICE AND OTHER OBSTRUCTIONS—1927

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Jan. 1	1	Cape Race (station)	47 02	47 47	Berg.
1	2	do	48 02	47 49	Do.
1	3	do	48 04	51 23	Do.
1	4	do	47 43	50 11	Small berg and growler.
1	5	do	47 42	46 22	Growler.
Feb. 8	6	do	20 miles East Bull Head		Berg.
10	7	do	47 43	48 41	Small berg.
10	8	Oxonian	45 52	57 20	Thick field ice.
12	9	Cape Race (station)	47 00	47 41	Large berg.
13	10	Incemore	46 07	47 12	Berg.
13	11	Cape Race (station)	46 40	47 42	Do.
13	12	do	46 35	47 30	Small berg.
13	13	do	46 06	47 12	Berg, same as 10.
13	14	do	45 58	47 29	Do.
15	15	do	46 02	46 25	Do.
15	16	do	44 56 to 45 00	60 00 to 60 06	Patches of field ice.
19	17	do	48 20 to 47 50	50 00 to 50 05	Field ice.
19	18	do	47 50	50 25	Berg.
19	19	do	46 55	61 25	Field ice.
20	20	do	45 30	53 17	Berg and heavy slob ice.
21	21	Stockholm	44 22	62 41	Large growlers.
21	22	Cape Race (station)	47 05	49 12	Small berg.
22	23	do	46 45 to 46 30	51 17 to 52 10	Slob ice in all directions.
22	24	do	46 05	49 12	Small berg.
24	25	do	46 34	52 23	Large berg, same as 20.
24	26	do	2 miles S. E. Renews Rock		Do.
25	27	do	47 31 to 47 14	47 48 to 47 36	Field ice and growlers.
25	28	do	46 55	47 23	Field ice and small bergs.
25	29	do	5 miles East Cape Race		Berg.
25	30	Hellig Olav	46 56	47 23	Field ice extending north and south.
26	31	Cape Race (station)	45 22	54 27	Field ice.
26	32	do	46 00	47 30	Field ice extending 10 miles north and south.
26	33	Hellig Olav	45 30 to 45 40	54 00 to 54 35	Field ice, same as 31.
27	34	do	44 52 to 44 46	60 10 to 60 50	Heavy field ice, same as 16.
28	35	Cape Race (station)	46 25	47 15	Growlers and field ice.
28	36	do	46 50	47 30	Drift ice.
Mar. 2	37	do	46 12	47 13	Small berg and northward field ice.
6	38	do	48 10	48 00	Drift ice.
7	39	do	12 miles S. W.		Tall berg and light slob ice.
10	40	Vela	47 00	50 30	100 miles of field ice to the eastward.
13	41	Cape Race (station)	47 00	47 00	Large berg.
14	42	do	48 30	49 30	Large berg and field ice.
14	43	do	46 36	46 48	Do.
14	44	do	46 47	48 05	Two small bergs and some growlers.
14	45	do	47 35	47 26	Large berg.
18	46	do	47 05	46 59	Do.
18	47	do	47 58 to 46 50	48 45 to 46 47	Ice field.
19	48	do	46 30	46 46	Berg.
19	49	do	46 20	45 50	Do.
19	50	do	46 30	45 54	Dangerous growlers and small pieces.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north (° ′)	Position: Longitude, west (° ′)	Nature of ice or obstruction
Mar. 20	51	Cape Race (station)	45 54	47 37	Large berg.
20	52	do	45 55	47 40	Do.
20	53	do	45 53	47 51	Growler.
22	54	do	45 31	47 13	Large berg.
22	55	do	45 34	47 03	Do.
22	56	do	45 35	46 39	Do.
22	57	do	46 47	43 19	Do.
22	58	do	45 51	45 41	Berg.
22	59	do	45 50	45 41	Large berg.
22	60	do	45 58	45 40	Do.
22	61	do	46 03	46 10	Growler.
22	62	do	45 52	46 53	Berg.
22	63	do	45 58	47 02	Do.
23	64	do	46 47	44 31	Large berg.
24	65	do	46 23 to 46 15	47 59 to 47 53	Field ice with large pieces.
24	66	do	45 47	43 48	Large berg.
24	67	do	45 14	46 25	Do.
25	68	do	45 18	45 42	Do.
27	69	do	44 56	45 49	1 berg; 2 growlers.
27	70	do	202° from Cape Race		Berg, same as 39.
23	71	do	40 55	52 32	Derelict "Ann Belle Cameron."
27	72	do	44 00	49 00	Large berg, 2 growlers.
28	73	do	46 23 to 46 44	47 47 to 47 21	Field ice, same as 65.
28	74	do	202° 1	11 miles	Same as 70 and 39.
28	75	do	46 45	42 30	Berg.
29	76	Tyrifjord	44 40	48 10	Do
29	77	do	44 55	48 34	Small berg.
29	78	do	44 47	48 47	Growler.
29	79	do	44 50	48 48	Small berg.
29	80	do	44 45	48 50	Growler.
29	81	do	44 48	48 54	Do.
30	82	Ice patrol (T)	44 28	48 44	2 small bergs, same as 77.
30	83	do	44 21	48 26	2 small bergs, same as 79.
30	84	do	43 56	49 03	Growler, same as 72.
30	85	Scandia	45 18	48 10	Large berg.
30	86	do	45 12	48 00	Do.
30	87	Cairnvalonia	44 41	49 00	Medium berg.
31	88	Estonia	46 35	47 30	Heavy field ice.
31	89	do	45 52	49 30	Medium berg.
31	90	do	45 45	49 23	Growler.
31	91	do	45 40	49 40	Large berg and growler.
31	92	do	45 40	49 47	Do.
31	93	Cairnvalonia	45 30	46 35	Small berg.
Apr. 1	94	Schenectady	44 18	48 50	1 berg and 1 growler.
1	95	Chicago	47 15 to 47 30	48 00 to 48 05	Dense ice field.
1	96	do	46 14	48 10	Large berg.
1	97	Auronia	44 18	48 51	1 berg and 1 growler, same as 94.
1	98	Minnie Larrinage	39 33	48 59	Derelict Anna Belle Cameron, same as 71.
1	99	Doric	46 05	49 32	Growler.
2	100	Phoebus	42 05	50 28	Do.
2	101	Iroquois	40 09	52 51	Derelict about 30 feet long.
3	102	Cairnesk	43 50	48 34	Berg.
3	103	do	43 36	48 50	Small berg.
3	104	Mount Royal	41 02	46 20	Gas buoy.
3	105	United States	42 53	49 11	Small berg.
4	106	Devon	43 08	49 08	Growler.
4	107	Bay State	44 18	48 31	Berg.
4	108	Gypsum King	47 29 to 46 22	48 00 to 47 10	Heavy field ice, same as 6.
4	109	Bergensfjord	43 36	48 52	Large growler, same as 102.
4	110	Ice patrol (T)	42 53	49 32	Berg, same as 105.
4	111	do	42 58	49 28	Growler, same as 106.
5	112	Cairnmona	45 02	48 57	Large berg.
5	113	Cape Race (station)	46 37	52 58	Large berg, drifting south.
5	114	Gypsum King	44 41	48 38	Large berg.
6	115	Sachem	47 30 to 46 14	52 35 to 51 15	Field ice.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Apr. 6	116	Sachem	46 32	52 36	Berg, same as 113.
6	117	America	46 47 to 47 05	52 31 to 51 40	Heavy field ice, numerous bergs, and growlers.
6	118	do	46 40 to 46 25	52 30 to 51 30	Heavy field ice.
6	119	Mexico	47 00 to 45 30	46 20 to 47 40	Field ice.
6	120	do	45 25	47 50	2 small bergs.
6	121	Canadian Victor	43 36	49 01	Small berg.
7	122	Sachem	46 40 to 46 05	50 00 to 47 40	Field ice to northward on Banks.
7	123	do	45 50	47 20	Low berg.
7	124	Independence Hall	43 16	49 25	Berg, same as 121.
7	125	do	43 21	49 42	Berg.
7	126	America	45 51	48 11	Large berg.
7	127	Mexico	44 43	49 47	Large berg, same as 92.
7	128	Baron Garioch	43 32	48 38	Large berg.
7	129	Ice patrol (T)	43 23	49 22	Berg, same as 125.
7	130	do	43 24	49 41	Berg, same as 124.
9	131	Hellig Olav	45 08	48 28	2 small growlers.
9	132	Balfour	42 54	49 52	Large berg.
9	133	Cape Race (station)	39 45	47 59	Derelict Anna Belle Cameron.
10	134	Ala	46 12	48 15	Light field ice.
10	135	do	46 28	47 42	Ice field.
10	136	do	46 51	47 35	Do.
10	137	do	47 05	47 25	Do.
10	138	Trolleholm	46 35 to 45 25	48 30 to 48 35	Do.
10	139	Ala	45 42	49 00	Large berg.
10	140	do	45 45	48 56	Berg.
10	141	Trolleholm	45 14	49 42	Large berg.
11	142	Lord Antrim	46 28 to 45 30	47 10 to 48 00	Field ice.
11	143	Lord Devonshire	43 42	49 18	2 bergs.
11	144	do	43 51	49 26	Growler.
11	144a	Annavore	44 40	48 51	Large berg.
11	145	Ice patrol	42 43	49 45	Berg.
12	146	Athenia	43 38	49 06	Berg and growler, same as 144.
12	147	Wolsum	43 38	49 33	2 small bergs, same as 144.
12	148	Athenia	44 08	48 30	Large berg.
12	149	Lord Downshire	44 13	48 22	2 small bergs, same as 148.
12	150	Newfoundland	46 50	47 00	Field ice extending north and south.
12	151	Brandon	43 12	49 18	2 growlers.
12	152	Newfoundland	46 08	48 32	Berg.
12	153	Sinasta	40 00	48 51	Derelict Anna Belle Cameron.
13	154	Aurania	45 11	48 46	Small berg.
13	155	do	45 14 to 45 31	48 36 to 47 25	Open ice field.
13	156	Yorck	42 49	50 10	1 growler.
13	157	Luossa	40 03	49 00	Derelict Anna Belle Cameron.
13	158	Bengasi	43 54	49 19	Berg and growlers.
14	159	Brant County	44 15	48 47	Berg.
14	160	Lucerna	43 03	50 04	Growlers, same as 145.
14	161	Cairnesk	44 06	49 32	Berg.
14	162	do	43 55	49 28	Do.
14	163	Copeman	42 55	50 34	2 bergs, same as 145.
14	164	Holly Park	44 30	48 58	Small growler.
15	165	Regina	45 47	49 14	Berg.
15	166	Estonia	41 55	52 05	Heavy log.
15	167	Regina	46 11	48 46	Berg.
15	168	do	46 26	47 56	Small berg.
15	169	Tampa S. S	44 12	48 55	Large berg.
15	170	Cape Race	46 21	46 58	2 growlers.
15	171	do	46 28	47 14	Large berg.
16	172	Regina	46 42 to 46 45	47 22 to 46 56	Field ice.
15	173	Cairnross	43 57	48 47	Berg.
16	174	Hjelmasen	43 42	48 27	Berg, same as 173.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Apr. 16	175	Colonian	46 09 to 45 59	46 50 to 47 17	Field ice, same as 172.
16	176	Metagama	43 42	48 27	Small berg, same as 173.
16	177	do	43 57	48 18	Large berg, same as 174.
16	178	Alchiba	46 28	47 14	Berg, same as 171.
16	179	do	45 52	48 55	Do.
16	180	do	45 49	48 59	Do.
16	181	do	46 21	46 58	2 growlers, same as 170.
16	182	Ice patrol (M)	43 52	48 09	Berg, same as 173.
16	183	do	43 36	48 23	Berg, same as 174.
17	184	Alphard	44 30	47 58	Berg.
17	185	Bayou Chico	39 35	49 33	Derelict Anna Belle Cameron.
18	186	Ariano	46 17	47 37	Small bergs.
18	187	do	46 22	47 46	Small bergs and growlers.
18	188	do	46 15	48 25	Large berg.
19	189	Ascania	44 52 to 44 18	59 19 to 58 49	Heavy field ice (31 bergs to date).
19	190	Montrose	47 13	47 15	Berg.
19	191	Delaware	42 19	50 02	Heavy log, 30 feet long.
19	192	Montrose	47 12	47 27	Field ice.
20	193	Samatario	44 50	49 30	Berg.
20	194	Bolingbroke	46 38	47 39	Field ice, some heavy pieces.
20	195	Sylvia	44 25	60 00	Field ice, with many growlers.
20	196	Ravanger	46 44	47 40	Field ice and to the northward.
20	197	Ice patrol (M)	44 12	48 54	Berg.
20	198	Montrose	47 12 to 46 47	47 27 to 47 43	Field ice.
20	199	Motocarlin	39 30	47 12	Derelict Cameron.
20	200	Alaunia	46 40	48 15	Berg.
20	201	Bolingbroke	46 16	48 26	Do.
20	202	Ice patrol (M)	44 42	49 13	Do.
20	203	do	44 50	49 30	Berg, same as 193.
20	204	Concordia	43 30	49 31	Berg, same as 197.
20	205	Alaunia	46 28	48 37	Do.
20	206	do	46 22	48 53	Do.
20	207	Ascania	46 10	48 14	Berg, same as 205.
20	208	City of Glasgow	46 49	47 10	Small berg.
20	209	Ascania	46 07	48 21	Field ice.
20	210	City of Glasgow	46 36	47 40	Field ice (39 bergs).
21	211	Lituania	45 21	48 51	Small berg.
21	212	Bay State	44 04	48 23	Berg.
21	213	Montroyal	46 40	48 10	Berg, same as 200.
21	214	do	46 32	47 58	Berg.
21	215	do	46 41	48 09	Do.
21	216	do	46 32	48 38	Berg, same as 205.
21	217	do	46 30	39 05	Berg.
21	218	Montroyal	46 46 to 46 38	48 14 to 47 45	Field ice.
21	219	Fanad Head	46 16	47 51	Southern end of field ice.
21	220	do	46 12	48 12	Berg.
21	221	Lituania	45 33	49 37	Small growlers.
21	222	Parthenia	46 00 to 45 50	47 50 to 48 10	Field ice, light and open.
21	223	do	45 55	47 50	Berg, same as 186.
21	224	do	46 00	48 20	Berg, same as 187.
21	225	Fanad Head	46 58	47 33	Field ice, eastern edge.
21	226	Burgerdijk	40 36	50 58	Light buoy showing red flashes.
21	227	Ice patrol (M)	43 37	49 38	Berg, same as 197.
21	228	Marte	43 31	41 13	Large buoy superstructure.
22	229	Stavangerfjord	44 21	49 08	Small growler.
22	230	Marte	44 38	47 38	Berg, same as 212.
22	231	Gorm	46 40	48 30	Berg.
23	232	Montreal	45 56	47 18	Do.
23	233	Marte	45 04	49 20	Berg, same as 211.
23	234	Nova Scotia	46 40	47 40	2 miles field ice, open and scattered.
23	235	do	46 40	47 40	Small berg and growlers.
23	236	do	46 50	49 00	Berg.
23	237	do	46 40	48 30	Berg, same as 231.
23	238	do	46 40	48 00	Berg and growler.
23	239	Canadian Rancher	44 55 to 44 29	59 25 to 59 05	Slob ice (from St. Lawrence).

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
Apr. 23	240	Cape Race	46 22	46 48	Berg.
23	241	do	45 58	48 30	Berg and isolated patches field ice.
23	242	do	48 42 to 48 38	47 54 to 48 08	Southern edge of an ice field
23	243	do	48 32	45 33	Growler.
23	244	do	46 45	47 30	Narrow ice field extending north and south.
23	245	Maidenhead	46 00	47 36	Scattered field ice.
25	246	Montclare	42 58	51 00	Berg.
25	247	Salina	47 03	48 45	2 large bergs.
26	248	do	47 00	49 56	Berg.
26	249	Arna	48 48 to 48 06	49 40 to 49 17	Ice field.
26	250	do	48 05 to 47 50	47 20 to 48 44	Field ice and several growlers.
26	251	Ice patrol	42 58	51 00	Berg, same as 246.
27	252	Southerland	45 38	48 57	Berg.
27	253	Sulina	42 33	59 35	Buoy, conical shape.
27	254	Seven Seas Trader	46 08	47 54	Growler.
27	255	Albertic	46 33	48 32	Berg, several growlers.
27	256	Clearpool	44 55	50 17	Berg and growlers.
27	257	Polan Hall	47 27	49 23	2 and 2 small bergs.
27	258	do	46 59	52 35	Large berg.
27	259	do	46 38	52 20	Medium berg.
27	260	Albertic	45 46	49 44	Small berg.
28	261	Ivar	48 40 to 48 30	48 45 to 48 55	Field ice.
29	262	do	48 14	48 50	Edge of ice field.
29	263	Letitia	46 10	50 15	Growler.
29	264	Ivar	48 30	49 00	Heavy ice field.
30	265	Newfoundland	47 40	52 20	Berg and growlers.
30	266	do	47 37	52 79	Do.
30	267	do	47 40	52 12	Do.
30	268	do	47 38	51 38	Do.
30	269	Manchester	47 50	48 23	Growler.
30	270	do	47 48	48 27	Do.
30	271	do	47 40	48 47	Do.
30	272	do	47 23	49 29	Do.
30	273	do	49 22	49 38	Do.
30	274	do	47 18	49 46	Do.
30	275	do	47 14	49 49	Do.
30	276	do	47 30	49 49	Do.
30	277	do	47 27	49 53	Do.
30	278	do	47 27	49 57	Do.
30	279	do	47 20	49 49	Do.
30	280	do	47 27	49 53	Growler, same as 277.
30	281	do	47 27	49 57	Growler, same as 278.
30	282	do	47 21	50 03	Growlers.
30	283	Newfoundland	47 45	50 50	35 large bergs and numerous small ones.
May 1	284	Cape Race (station)	48 00 to 49 00	47 30 to 49 15	Field ice.
1	285	do	47 40	49 40	Several large bergs, vicinity.
2	286	Suderoy	46 57	47 08	Small berg and growler.
2	287	Samaria	41 56	63 13	Bell buoy.
2	288	Caringowan	48 56 to 48 06	49 06 to 50 44	Heavy field ice.
2	289	do	48 06	50 44	14 bergs and growlers, same as 285.
3	290	Gallier	42 52	42 55	Wreckage, 20 feet long, 4 feet wide.
4	291	Panjalo	47 40	48 45	Several growlers.
5	292	Minnendosa	46 32	53 25	1 berg.
5	293	Regina	46 40	48 34	2 growlers.
5	294	Cape Race (station)	46 55	52 48	Large berg, same as 258.
5	295	do	46 40	53 00	Several growlers in vicinity.
5	296	Suderoy	46 55	52 48	1 large berg, same as 258.
5	297	do	47 20	52 35	Medium berg, aground.
5	298	Ice patrol (T)	47 34	49 00	Berg.
5	299	do	47 30	48 55	Do.
5	300	do	47 23	49 10	Do.
5	301	do	47 27	49 11	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 5	302	Ice patrol (T)	47 33	49 42	Berg.
5	303	do	47 36	49 40	Do.
5	304	do	47 35	50 09	Do.
5	305	do	47 36	50 26	Do.
5	306	do	47 36	50 34	Do.
5	307	do	47 26	49 52	Do.
5	308	do	48 00 to 47 34	49 46 to 50 23	Field ice.
5	309	Huronian	46 28	48 43	Large berg.
6	310	Modavia	46 39	47 40	Large growler.
6	311	Manchester Commerce	46 12	48 35	Large berg.
6	312	Ice patrol (T)	47 50 to 47 30	50 30 to 51 00	About 100 icebergs.
6	313	Ikala	46 10	49 09	Berg.
6	314	Modavia	46 05	48 48	Large berg.
6	315	Topsdalfjord	47 18	50 35	Several large and small bergs.
6	316	Albatros	46 14	48 39	Berg and growler.
7	317	Lituania	47 00	49 05	Large berg.
7	318	do	46 48 to 47 12	48 47 to 48 20	Numerous growlers.
7	319	Cairnglen	47 23	49 45	Berg and growlers, same as 312.
7	320	do	47 20	49 48	Berg.
7	321	do	47 21	49 54	2 bergs, same as 312.
7	322	do	47 20	50 26	1 berg, same as 312.
7	323	do	47 09	50 30	Berg, same as 312.
7	324	do	47 11	50 33	Detached ice, same as 312.
7	325	Comino	46 45	47 30	5 growlers.
7	326	do	46 35	48 00	Berg.
7	327	Cadore	48 00 to 47 36	48 40 to 49 21	Several hundred growlers.
8	328	Oceanic	47 15	48 40	Several bergs.
8	329	Gracia	46 10	48 41	Berg.
8	330	Lord Downes	46 52	48 00	Large growler.
8	331	Stockholm	42 37	63 31	Large black buoy.
9	332	Cape Race (station)	48 27	49 10	Numerous bergs and growlers.
9	333	Schouwen	47 15	48 50	1 growler.
9	334	do	47 19	48 40	3 growlers.
9	335	do	47 10	49 29	1 growler.
9	336	Ice patrol (M)	46 08	48 42	Berg, same as 329.
9	337	Schouwen	46 53	50 30	Berg.
9	338	Dalworth	47 10 to 47 10	49 50 to 51 00	15 bergs.
9	339	Montcalm	46 35	49 40	Berg.
9	340	do	46 55	48 55	Do.
9	341	do	46 49	48 55	Growlers.
9	342	do	46 53	48 45	Growler.
10	343	Moveria	46 08	48 42	Berg and growler, same as 336.
10	344	Nova Scotia	48 30 to 48 00	49 30 to 51 25	50 bergs; 100 growlers.
11	345	Canadian Commander	45 50	48 31	Berg, same as 336.
11	346	Cape Race (station)	47 37 to 47 20	50 57 to 50 45	Numerous bergs and field ice, same as 312.
11	347	Estonia	47 13	48 38	Growler.
11	348	do	46 11	49 02	Do.
11	349	do	48 10	49 15	Do.
11	350	do	48 15	48 14	Berg.
11	351	do	47 10	49 19	Do.
11	352	do	47 05	49 31	Do.
11	353	do	46 58	49 54	Do.
11	354	do	46 58	50 13	Do.
11	355	do	47 06	49 22	Growler.
11	356	do	46 58	50 13	Do.
12	357	Caronia	43 32	43 00	Gas buoy "A-6."
12	358	Cape Race (station)	47 02 to 47 07	51 00 to 50 40	16 bergs, same as 338
12	359	do	47 24	48 32	Berg.
12	360	do	47 27	49 12	Do.
12	361	do	47 22	49 37	2 growlers.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north °	′	Position: Longitude, west °	′	Nature of ice or obstruction
May 8	362	Cape Race (station)	39	30	39	03	Derelict Anna Belle Cameron.
12	363	Lapland	46	24	47	59	Growler.
12	364	Missouri	46	11	47	30	Do.
13	365	Cape Race (station)	45	27	56	17	Red buoy "F4."
13	366	do	41	09	53	26	Black gas buoy.
13	367	do	46	28	47	39	Growler.
13	368	do	46	11	47	30	Growler, same as 364.
14	369	Oakworth	45	54	47	50	Growler.
13	370	Cape Race (station)	46	56	48	10	Do.
13	371	do	46	49	49	14	3 growlers.
13	372	do	46	46	49	51	Berg.
13	373	do	46	08	47	57	Growler.
13	374	do	47	20	47	20	Do.
13	375	do	47	19	52	24	2 growlers.
14	376	Landaas	46	15	48	56	Berg and growler.
14	377	Lord Kelvin	45	20	44	50	Berg.
14	378	Cape Race (station)	43	41	42	06	Can buoy.
14	379	do	45	54	47	50	Growler, same as 369.
14	380	do	46	42	49	56	Berg.
14	381	do	46	38	50	14	Do.
15	382	do	46	28	53	12	Do.
15	383	Liberty	41	57	49	53	Growler.
15	384	Cape Race (station)	47	41	51	18	Berg.
15	385	do	46	18	53	12	Do.
15	386	Andania	46	41	52	54	Do.
16	387	Canadian Planter	46	45	50	16	Do.
16	388	Andania	46	40	52	51	Do.
16	389	do	46	54	52	49	Do.
16	390	do	46	40	52	38	Do.
16	391	Gorm	46	45	53	00	Do.
16	392	do	47	15	51	48	Growlers and berg.
16	393	do	47	30	51	25	Berg.
16	394	do	47	52	50	40	2 bergs, growlers.
16	395	Cape Race (station)	45	55	55	30	Tree.
16	396	do	48	30	49	20	Berg.
16	397	Andania	47	21	49	02	Growler.
17	398	Cape Race (station)	46	40	50	09	Berg.
17	399	do	47	00	49	47	Do.
17	400	do	46	47	49	33	Do.
17	401	do	46	56	49	40	Berg and growler.
17	402	do	46	52	49	11	Growlers.
17	403	do	47	13	48	33	Do.
17	404	do	47	11	48	19	Do.
17	405	do	47	48	50	51	Berg.
17	406	do	47	51	51	00	Do.
17	407	do	47	46	50	43	Do.
17	408	do	47	55	50	41	Do.
17	409	do	47	55	50	26	Do.
17	410	do	48	06	50	22	Do.
17	411	do	50	24	50	12	Do.
17	412	Lehigh	42	15	45	14	Log.
17	413	Melita	47	35	50	00	Berg.
19	414	Baron Sempill	40	38	45	44	Spar.
19	415	Svir	47	42	44	39	Berg.
18	416	Cape Race (station)	46	37	53	14	Do.
18	417	do	47	18	50	32	Do.
19	418	do	47	31	50	36	Do.
19	419	Melita	47	41	50	36	Growler.
19	420	do	47	39	50	43	Berg.
19	421	do	47	38	50	48	Do.
19	422	do	48	36	51	02	Do.
21	423	Calgaric	47	29	50	57	Do.
21	424	do	47	28	50	52	3 bergs.
21	425	do	47	23	50	49	Berg.
21	426	do	47	33	50	43	Do.
21	427	do	47	20	50	44	Do.
21	428	Cape Race (station)	47	21	49	44	Do.
21	429	do	47	18	49	36	Do.
21	430	do	48	05	49	00	3 bergs, same as 9th.
21	431	do	47	51	48	37	Berg.
21	432	Ocenia	46	42	48	06	Berg and growlers.
21	433	Calgaric	47	38	50	42	22 bergs, same as 312.
21	434	do	47	40	50	45	3 bergs, same as 312.
21	435	do	47	33	50	32	Berg, same as 312.
21	436	do	47	34	59	33	Do.
21	437	do	47	34	50	26	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 21	438	Calgaric	47 42	50 32	Berg, same as 312.
21	439	do	47 37	50 24	Do.
21	440	do	47 43	50 27	Three growlers, same as 312.
21	441	do	47 35	50 19	Berg, same as 312.
21	442	do	47 39	50 08	Do.
21	443	do	47 49	49 52	Do.
21	444	do	47 50	49 49	Do.
21	445	do	47 51	49 29	Do.
21	446	do	47 54	49 37	Do.
21	447	do	48 00	49 32	Berg and growlers.
21	448	Frode	46 40	46 50	2 bergs.
21	449	Cape Race (station)	48 31	49 19	Growler.
21	450	do	48 20	49 22	Berg and 4 growlers.
21	451	do	48 25	49 27	Berg.
21	452	do	48 22	49 33	Do.
21	453	do	48 15	49 42	Do.
21	454	do	48 18	49 42	Do.
21	455	do	48 13	49 48	Do.
21	456	do	48 26	49 34	2 bergs.
21	457	do	48 10	49 54	Berg and growlers.
21	458	do	48 12	49 58	Do.
21	459	do	46 40	46 59	2 bergs.
21	460	do	47 33	48 15	Berg and growler.
21	461	do	47 20	49 18	Bergs.
21	462	do	47 32	49 40	Do.
21	463	do	47 26	49 16	2 bergs.
21	464	do	47 24	49 50	Berg and growlers.
21	465	do	47 12	50 10	Huge berg and growlers.
21	466	do	48 26	49 07	Berg.
21	467	do	48 12 to 47 50	47 40 to 50 40	25 bergs and 75 growlers.
22	468	do	47 30 to 47 30	50 40 to 50 50	14 large bergs.
22	469	do	47 35	52 38	2 bergs.
22	470	do	47 40	49 41	Berg.
22	471	Hada	47 25	50 45	25 bergs, many growlers, same as 467.
22	472	Cape Race (station)	46 42	52 47	Berg.
22	473	do	46 37	53 10	Do.
23	474	Ascania	46 52	52 31	Do.
23	475	Texas Maru	46 21	46 47	Do.
23	476	Skipsea	46 43	47 39	Berg and growlers.
23	477	Ice patrol (M)	46 05	48 00	Growler.
23	478	do	46 19	47 56	Berg and growler, same as 432.
23	479	Anaconda	43 46	49 43	Whale belly up.
23	480	Cape race (station)	46 39	53 03	Berg.
23	481	do	48 11 to 47 21	46 40 to 52 30	44 bergs, several growlers, same as 467.
23	482	do	46 21	46 47	Berg, same as 475.
23	483	Asconia	47 20	50 19	Berg.
23	484	do	47 16	50 09	Growler.
23	485	do	47 19	49 46	Berg.
23	486	do	47 14 to 47 15	49 43 to 49 39	Several pieces of ice.
23	487	do	47 17	49 33	Berg.
23	488	do	47 20	49 21	Do.
23	489	do	47 29	48 58	Do.
23	490	do	47 23	48 57	Do.
23	491	do	47 31	48 25	Do.
23	492	do	47 44	48 35	Do.
23	493	do	47 47	48 08	Do.
23	494	do	47 48	48 10	Do.
23	495	do	47 53	47 55	Do.
24	496	do	47 50	47 42	Do.
24	497	do	47 49	47 35	Berg and 3 growlers.
24	498	do	48 02	47 25	Berg.
24	499	Beemsterdyk	47 47	48 03	Do.
24	500	Montroyal	47 50	49 15	Berg, same as 467.
24	501	do	47 49	49 20	Do.
24	502	do	47 38	49 23	Do.
24	503	do	47 46	49 25	Do.
24	504	Beemsterdyk	47 10	50 20	Berg.
24	505	do	47 13	50 20	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 24	506	Megantic	47 25	50 41	Berg, same as 467.
24	507	do	47 19	50 27	Do.
24	508	do	47 21	50 28	Do.
24	509	do	47 36	50 26	Do.
24	510	do	47 33	50 16	Do.
24	511	do	47 37	50 18	Do.
24	512	do	47 35	50 12	Do.
24	513	do	47 42	50 15	Do.
24	514	do	47 30	49 57	Do.
24	515	do	47 45	50 09	Do.
24	516	do	47 37	49 51	Do.
24	517	Cairngowan	46 34 to 48 19	53 09 to 50 08	Numerous bergs; growlers and small pieces of ice.
24	518	Watuka	47 46	52 41	Berg.
24	519	do	47 32	52 30	Do.
24	520	Montroyal	47 42	49 26	Growler, same as 481.
24	521	do	47 35	49 32	Berg and pieces of ice, same as 481
24	522	do	47 40	49 32	Berg, same as 481.
24	523	do	47 29	49 50	Growler, same as 481.
24	524	do	47 37	50 00	2 bergs, same as 481.
24	525	do	47 17	50 00	Berg, same as 481.
24	526	do	47 36	50 03	Do.
24	527	do	47 24	50 24	Do.
24	528	do	47 19	50 24	Do.
24	529	Megantic	47 25 to 48 07	50 41 to 48 32	31 bergs and growlers, same as 467.
24	530	Beemsterdyk	46 49	52 36	Berg.
24	531	Ice patrol (M)	47 16	49 04	Do.
24	532	Montroyal	46 49	52 33	Do.
24	533	Modavea	47 20	50 40	2 large bergs.
24	534	do	47 20 to 47 45	50 30 to 49 25	22 bergs, same as 529
24	535	do	47 45 to 48 12	49 25 to 48 37	12 bergs, same as 529.
25	536	Caledonia	47 29	48 00	Large berg.
25	537	do	47 35	47 37	Do.
25	538	do	47 32	47 34	Small berg.
25	539	do	47 36	47 31	Large berg.
25	540	Pajala	47 17	52 35	Berg.
25	541	do	47 22	52 29	Do.
25	542	Rindijk	47 16 to 47 31	50 25 to 49 37	Several large bergs, same as 534.
25	543	Montroyal	46 37	52 36	Berg.
25	544	do	46 47	52 33	Berg, same as 632.
25	545	Pajala	47 30 to 46 40	52 40 to 53 00	Several growlers.
25	546	Brecon	47 16	47 20	Berg.
25	547	Albertic	47 09	49 44	Do.
25	548	do	47 25	48 46	Do.
25	549	do	47 23	48 54	Do.
25	550	do	47 18	49 04	Berg and growler.
25	551	do	47 08	49 27	Berg.
25	552	do	47 09	49 59	Do.
25	553	Canadian Leader	46 41	52 58	2 growlers.
25	554	Berwyn	47 14	50 14	Berg.
25	555	do	47 06	49 48	Do.
25	556	do	47 09	49 34	Berg, same as 551.
25	557	Norefjord	46 39	49 51	Berg.
25	558	Cape Race (station)	47 46	52 41	Do.
25	559	do	47 46	49 09	Berg and numerous growlers
25	560	do	46 33	52 40	Berg.
25	561	do	47 17	52 35	Do.
25	562	do	47 22	52 29	Do.
26	563	Canadian Leader	46 31	52 42	Berg, same as 560.
26	564	do	46 43	52 41	2 bergs.
26	565	do	46 46	51 15	Berg.
26	566	do	47 03 to 47 18	50 34 to 49 46	Numerous bergs and growlers, same as 34.
26	567	Golden Gate	46 46	47 12	Large berg.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
May 26	568	Ice patrol	46 25	48 13	Berg.
26	569	do	46 37	48 48	Do.
26	570	do	46 45	48 44	Do.
26	571	do	47 00	48 54	Do.
26	572	Lord Downshire	46 21	49 48	Berg, same as 569.
26	572a	do	46 24	49 43	Berg, same as 570.
26	573	Arnomendi	46 43	47 26	Berg, same as 491.
26	574	Enggano	46 40	46 56	Berg, same as 567.
26	575	Alaunia	47 21 to 47 02	50 07 to 51 27	53 bergs and numerous growlers.
26	576	Pajala	48 25	51 29	Berg.
26	577	Pennland	46 50	47 28	Do.
26	578	do	46 54	47 28	Growler.
26	579	do	46 45	47 35	Berg.
26	580	do	46 27	48 43	Do.
26	581	Lord Downshire	46 40	48 30	3 bergs and 4 growlers.
27	582	Pennland	46 05	49 26	Berg.
27	583	Letitia	47 33	50 53	Do.
27	584	Concordia	45 42	52 31	Growler.
27	585	Breedyk	46 04	52 27	Berg.
27	586	Letitia	47 09	51 42	Do.
27	587	do	47 03	51 40	Berg and growler.
27	588	do	47 01	51 58	Scattered pieces of ice.
27	589	do	46 55	52 00	Berg.
27	590	do	46 47	52 09	Do.
27	591	Moveria	37 04	47 49	Do.
27	592	do	47 07	47 49	Growler.
27	593	do	46 52	48 10	Do.
27	594	do	46 44	48 23	Do.
27	595	Cape Race (station)	46 04	52 27	Berg, same as 585.
27	596	do	48 00	50 52	Berg.
28	597	do	47 00	52 30	Berg and growlers.
28	598	do	46 28	46 38	Berg.
28	599	Breedyk	46 28	46 38	Berg, same as 598.
29	600	Brandon	46 46	51 00	Berg.
29	601	Blackheath	47 40	51 00	Berg and growlers.
29	602	Blairholm	47 14	49 31	Berg.
29	603	Melita	46 50 to 47 39	50 48 to 49 00	12 bergs, 10 growlers.
29	604	Yildum	46 53 to 47 07	50 52 to 49 55	20 bergs on both sides, Cape Race track, same as 575.
29	605	Shouwen	45 39	48 28	Berg.
29	606	Blairholm	47 06	50 16	5 bergs.
29	607	do	46 54	50 38	Berg.
29	608	do	46 48	50 38	Do.
29	609	do	46 35	50 31	Do.
29	610	do	46 55	50 31	Do.
29	611	Shouwen	45 33	47 54	Do.
30	612	Blair Logie	46 52	47 50	Berg and 3 growlers.
30	613	Greldon	46 01	48 28	2 growlers.
30	614	Emily Caron	46 02	47 12	Berg.
30	615	Montrose	46 54	51 44	Bergs.
30	616	do	47 00	51 27	Growler, same as 575.
30	617	do	47 03	51 17	Berg, same as 575.
30	618	do	47 12	51 08	Bergs.
30	619	do	47 08	51 05	Do.
30	620	do	47 13	51 02	Do.
30	621	do	47 19	50 59	2 bergs and growlers.
30	622	Emily Caron	46 28	46 31	Berg and several growlers.
30	623	Bellatrix	46 05	47 00	Berg.
30	624	Hartbridge	46 39	52 44	Do.
30	625	Simmonburn	47 40	50 48	Berg and 2 growlers.
30	626	do	47 28	49 55	Berg.
30	627	do	47 28	51 03	Do.
30	628	do	47 18	51 25	Do.
30	629	do	47 21	51 45	Do.
30	630	do	47 18	51 42	Do.
30	631	do	47 14	51 44	Berg and several growlers.
30	632	Cape Race (station)	47 12	49 03	Berg.
30	633	do	47 00	51 30	3 bergs and several growlers.
30	634	do	47 40	51 00	Berg and several growlers.
30	635	do	46 43	52 40	2 bergs.
30	636	do	47 02	47 12	Berg.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north ° ′	Position: Longitude, west ° ′	Nature of ice or obstruction
May 30	637	Cape Race (station)	46 39	52 44	Berg, same as 624.
30	638	do	47 40	50 48	Berg and 2 growlers, same as 625.
30	639	do	47 28	49 55	Berg, same as 626.
30	640	do	47 28	51 03	Berg, same as 627.
30	641	do	47 18	51 25	Berg, same as 628.
30	642	do	47 21	51 45	Berg, same as 629.
30	643	do	47 18	51 42	Berg, same as 630.
30	644	do	47 14	51 44	Berg and several growlers, same as 631.
30	645	Dubhe	47 30	48 50	Berg.
30	646	Montrose	47 18	50 38	17 bergs.
30	647	do	47 18	50 17	2 growlers.
30	648	do	47 38	50 11	Berg.
30	649	do	47 46	49 50	3 bergs.
30	650	Greldon	46 01	48 25	Berg.
31	651	Stal	45 00	45 40	Do.
31	652	Ice patrol (T)	45 28	48 24	Berg, same as 611.
31	653	Nikola Mibanovic	45 20	48 49	Berg, same as 605.
31	654	Grene	47 50 to 47 50	52 50 to 50 21	Several bergs and growlers.
31	655	Lumen	44 53	45 58	Berg, same as 651.
31	656	Winterswyk	46 05	52 51	Berg.
31	657	Doric	47 47 to 47 21	49 32 to 50 06	6 bergs, 4 growlers.
31	658	do	47 30 to 47 03	50 05 to 51 07	30 bergs, many growlers
31	659	Anglo Australia	47 39	52 53	Berg.
31	660	do	47 46 to 47 24	50 50 to 51 06	Several bergs.
31	661	do	47 50	51 00	Do.
31	662	Cape Race (station)	41 04	49 03	Derelict "Annabelle Cameron."
31	663	do	41 44	52 43	Wreckage.
31	664	do	47 47 to 47 11	50 18 to 51 44	Several bergs and growlers.
31	665	do	46 10	52 18	Berg.
31	666	do	46 25	52 14	Do.
31	667	do	46 11	52 14	Do.
31	668	do	48 04	48 11	Do.
June 1	669	Poljana	45 13	46 18	Do.
1	670	Minnedosa	47 49 to 47 13	49 34 to 51 15	25 bergs and six growlers.
1	671	do	46 41	52 47	Berg.
2	672	Cape Race (station)	47 06	50 19	Do.
2	673	do	47 03	50 19	Do.
2	674	do	46 41	52 47	Do.
2	675	do	46 40	53 00	Berg and several growlers.
2	676	Suderoey	48 05	52 18	Berg.
2	677	Andania	47 42	50 32	6 bergs, several growlers.
2	678	Regina	47 26 to 47 16	50 55 to 51 55	7 bergs, several growlers.
2	679	Andania	47 48 to 47 13	50 42 to 51 14	23 bergs; several growlers; same as 65[illegible]
2	680	do	47 16 to 47 05	51 54 to 52 06	3 bergs.
2	681	do	46 02	50 13	Do.
2	682	Cape Race (station)	47 21	49 55	Growler.
2	683	do	47 22	50 03	1 berg, 1 growler.
2	684	do	46 39	52 51	Berg.
2	685	do	47 35	48 50	Do.
3	686	Lituania	47 46	50 27	Do.
3	687	do	47 44	50 46	Do.
3	688	do	47 38	50 49	Growlers.
3	689	do	47 17	51 35	Berg.
3	690	London Commerce	42 48	43 59	Black buoy.
3	691	Cape Race (station)	47 23	49 20	Growlers.
3	692	do	47 16	51 54	Berg; same as 680.
3	693	do	47 11	51 58	Do.
3	694	do	47 04	52 06	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
June 3	695	Cape Race (station)	46 37	52 41	Berg.
3	696	do	47 00	47 49	Do.
3	697	do	47 50 to 46 50	49 30 to 52 55	6 bergs, several growlers.
3	698	Darnholm	46 22	46 26	Large berg.
3	699	Metagama	47 56	50 09	1 medium berg.
3	700	do	47 46	50 10	1 growler.
3	701	do	47 40	50 19	Do.
3	702	do	47 44	50 14	1 medium berg.
3	703	do	47 38	50 15	2 medium bergs.
3	704	do	47 39	50 15	Do.
3	705	do	47 32	50 34	1 medium berg.
3	706	do	47 33	50 36	2 medium bergs.
3	707	do	47 34	50 37	1 medium berg.
3	708	do	47 44	50 47	2 medium bergs.
3	709	do	47 29	50 56	1 medium berg.
3	710	do	47 32	50 57	1 small berg.
3	711	do	47 33	50 58	1 large berg.
3	712	do	47 23	51 17	1 table berg.
4	713	Montroyal	46 50	51 44	Berg.
4	714	do	46 37	51 31	Do.
4	715	do	46 52	52 34	Do.
4	716	do	47 16	50 11	Do.
4	717	Metagama	47 29	51 11	Do.
4	718	do	47 08	51 35	Berg and 2 growlers.
4	719	do	47 13	51 37	Berg.
4	720	do	47 04	51 42	Do.
4	721	Cape Race (station)	47 54	48 56	Do.
4	722	do	47 29	49 51	Do.
4	723	do	47 24	49 50	Do.
4	724	do	47 27	50 03	Do.
4	725	do	47 22	50 08	Do.
4	726	do	47 30	50 25	Do.
4	727	do	47 16	50 32	Do.
4	728	do	46 43	52 10	Do.
4	729	do	46 40	52 27	Do.
4	730	do	46 39	52 40	Do.
4	731	do	46 22	52 30	Do.
4	732	do	46 49	52 32	Do.
4	733	Ice patrol (T)	44 51	49 00	Small berg, same as 652.
5	734	Valcirusa	46 47	52 32	Berg.
5	735	do	46 35	52 21	Do.
5	736	Ellerdale	48 06	50 35	Do.
5	737	do	48 28	49 56	Do.
5	738	Innerton	47 33	51 12	Patch of field ice
5	739	do	47 59	50 18	Berg.
5	740	do	48 02	50 12	Do.
5	741	do	48 05	50 06	2 growlers.
5	742	do	48 15	49 39	Large berg.
5	743	Kentucky	47 23	51 26	Berg.
5	744	do	47 30	51 35	Do.
5	745	do	47 27	51 13	Growler.
5	746	Tampa	46 30	47 10	Do.
5	747	do	46 24	47 17	Berg.
5	748	do	46 28	47 27	Growler.
5	749	Ice patrol (T)	45 42	47 38	Berg.
5	750	do	45 48	47 42	Do.
5	751	do	45 57	47 50	Do.
6	752	do	47 04	49 36	Do.
6	753	do	47 03	49 20	Do.
6	754	do	46 58	49 29	Do.
6	755	do	47 00	49 48	Do.
6	756	do	46 49	49 49	Do.
6	757	do	46 53	49 56	Do.
6	758	do	46 55	50 01	Do.
6	759	do	46 51	50 02	Do.
6	760	do	46 55	50 08	Do.
6	761	do	46 56	50 10	Do.
6	762	do	46 59	50 12	Do.
6	763	do	46 58	50 20	Do.
6	764	do	47 18	49 25	Do.
6	765	do	47 19	49 30	Do.
6	766	do	47 19	49 50	Do.
6	767	do	47 19	49 51	Do.
6	768	do	47 27	49 55	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
June 6	769	Ice patrol (T)	47 15	50 00	Berg.
6	770	do	47 08	50 05	Do.
6	771	do	47 09	50 05	Do.
6	772	do	47 10	50 08	Do.
6	773	do	47 11	50 10	Do.
6	774	do	47 10	50 14	Do.
6	775	do	47 09	50 18	Do.
6	776	do	47 15	50 14	Do.
6	777	do	47 16	50 14	Do.
6	778	do	47 17	50 09	Do.
6	779	do	47 18	50 06	Do.
6	780	do	47 06	49 49	Growler.
6	781	do	47 07	49 53	Do.
6	782	Albertic	46 32	52 15	Berg.
6	783	Alaunia	46 34	52 18	Berg, same as 782.
6	784	do	46 50	52 24	Berg.
6	785	Letitia	46 33	52 12	Do.
6	786	do	46 47	52 18	Do.
6	787	North Anglia	46 32	52 18	Berg, same as 785.
6	788	Ice patrol (T)	46 35	52 20	Berg.
6	789	Alaunia	47 10	51 05	Do.
6	790	do	46 57	50 56	Do.
6	791	do	48 13	50 50	Do.
6	792	do	47 12	50 28	Do.
6	793	do	47 14 to 47 20	50 16 to 49 56	15 bergs, numerous growlers.
6	794	North Anglia	47 13	51 07	Berg.
6	795	Letitia	47 13	51 00	Do.
6	796	do	47 19	50 44	Do.
6	797	do	47 19	50 42	Do.
6	798	do	47 25	50 43	Do.
6	799	Balsam	47 48 to 47 07	50 12 to 52 06	11 bergs, 4 growlers.
6	800	do	46 47	52 50	Berg.
6	801	Alaunia	47 20 to 47 39	49 56 to 48 30	10 bergs, numerous growlers.
6	802	Letitia	47 23 to 47 54	50 34 to 49 16	19 bergs, numerous growlers.
6	803	North Anglia	47 08 to 47 25	51 11 to 49 46	Several bergs, many growlers.
6	804	Cape Race (station)	47 14	58 22	Black can buoy.
7	805	Calgaric	48 17	49 07	Berg.
7	806	do	47 54	50 10	Do.
7	807	Veendam	47 28	49 23	Berg and growler.
7	808	Calgaric	47 33	50 55	Berg and 2 growlers.
7	809	do	47 15	51 12	Berg.
7	810	do	47 30	51 12	Do.
7	811	Veendam	47 28	49 19	2 growlers.
7	812	do	47 27	49 21	Berg, same as 807.
7	813	do	47 14	50 09	Berg and 7 growlers, same as 809
7	814	do	47 17	50 28	Berg.
7	815	Calgaric	47 07	52 11	Growler.
7	816	Veendam	47 02	51 37	Berg.
7	817	Cape Race (station)	47 04	52 16	Do.
7	818	do	47 32	51 25	Berg, 5 growlers.
7	819	do	47 46	50 44	Berg.
7	820	do	46 05	50 30	Do.
7	821	do	48 20	50 10	Do.
7	822	Ice patrol (T)	47 28	52 23	Do.
7	823	do	47 07	51 55	Do.
8	824	do	46 50	52 55	Do.
8	825	Cape Race (station)	46 42	52 28	Do.
8	826	Moveria	47 50	50 04	Do.
8	827	do	47 41	50 18	Do.
8	828	do	47 31	50 52	Do.
8	829	do	47 07	51 35	Do.
8	830	Marburn	47 41	48 16	Do.
8	831	do	47 28	48 34	Do.
8	832	do	47 23 to 47 17	48 55 to 49 20	7 bergs, 4 growlers.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
June 8	833	Westpool	43 54	48 22	Growler.
8	834	Sulinac	45 55	46 21	Berg.
8	835	California	45 29	48 30	Do.
8	836	Kumara	48 09	51 10	Do.
8	837	California	45 44	47 32	Do.
8	838	Siberian Prince	47 30	48 25	Do.
8	839	Cairnross	47 40	51 11	Do.
8	840	do	48 05	50 20	Do.
8	841	do	47 30	51 11	Do.
8	842	do	48 05	50 10	Do.
8	843	do	48 10	50 10	Do.
8	844	do	48 20	50 00	Do.
8	845	Kia Ora	47 03	49 48	Do.
8	846	do	47 06	49 43	Do.
8	847	do	47 05	49 20	2 bergs.
8	848	do	47 20	48 30	Berg.
8	849	Kumara	47 37	52 00	Berg and several growlers.
8	850	Cape Race (station)	48 24	48 45	Berg.
8	851	do	48 01	49 34	Do.
8	852	do	47 54	49 47	3 bergs, 2 growlers.
8	853	do	47 50	49 54	Berg.
8	854	do	47 46	50 19	Do.
8	855	do	47 37	50 25	Do.
8	856	do	47 35	50 33	2 growlers.
8	857	do	47 17	51 23	Growler.
8	858	do	46 48	51 50	Berg.
9	859	Kia Ora	47 27	47 50	Do.
9	860	Antonia	47 52	47 57	Do.
9	861	Arabic	47 28	49 58	6 bergs within area of 10 miles.
9	862	do	47 32	50 01	Berg.
9	863	do	47 26	50 03	Do.
9	864	do	47 26	50 05	Do.
9	865	do	47 23	50 12	Do.
9	866	Megantic	47 42	50 22	Do.
9	867	do	47 46	50 56	Do.
9	868	do	47 26	51 23	Growler.
9	869	Montclare	48 06	49 44	Berg.
9	870	do	47 59	49 59	Do.
9	871	do	47 51	50 15	Growler.
9	872	Arabic	47 54	47 56	1 berg, 1 growler.
9	873	do	47 43	49 17	8 bergs.
9	874	do	47 45	49 09	Berg, several small pieces.
9	875	do	47 40	48 46	Berg.
9	876	do	47 41	48 30	Do.
9	877	do	47 50	48 56	Do.
9	878	do	47 56	48 57	Do.
9	879	Megantic	48 07	49 41	Do.
9	880	Leicester	47 55	47 55	Do.
9	881	do	47 49	48 20	Do.
9	882	Ice patrol	47 23	50 01	Do.
9	883	do	47 23	49 55	Do.
9	884	do	47 24	49 54	Do.
9	885	do	47 23	49 52	Do.
9	886	do	47 24	49 50	Do.
9	887	do	47 25	49 49	Do.
9	888	do	47 26	49 42	Do.
9	889	do	47 21	49 41	Do.
9	890	do	47 15	49 41	Do.
9	891	do	47 14	49 24	Do.
9	892	do	47 20	49 11	Do.
9	893	Megantic	48 10	49 54	Do.
9	894	do	48 01	49 55	Do.
9	895	do	47 55	49 49	Do.
9	896	do	47 54	49 48	Do.
9	897	do	47 56	50 14	Do.
9	898	Arabic	46 52	51 58	Berg; 2 growlers.
9	899	Cape Race (station)	47 35 to 47 32	49 12 to 49 17	6 bergs, numerous growlers.
9	900	do	47 20 to 47 13	49 48 to 50 10	5 bergs and growlers.
9	901	do	47 52	47 58	Berg.
9	902	do	47 47	52 03	Berg and growler.
9	903	do	47 31	49 26	Berg.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north	Position: Longitude, west	Nature of ice or obstruction
			° ′	° ′	
June 9	904	Cape Race (station)	47 31	49 35	Berg.
9	905	do	48 02	51 21	Do
10	906	Ice patrol (M)	47 10	49 20	Do.
10	907	do	47 16	49 17	Do.
10	908	do	47 11	49 08	Do.
10	909	do	47 14	49 06	Do.
10	910	do	47 29	49 18	Do.
10	911	do	47 16	49 05	Growler.
10	912	do	47 18	49 02	Do.
10	913	do	47 35	48 56	Berg.
10	914	do	47 16	48 51	Do.
10	915	do	47 16	48 48	Do.
10	916	do	47 20	48 46	Do.
10	917	Canadian Planter	46 51	52 02	Berg and growlers.
10	918	do	47 24	50 25	Large berg.
10	919	Huronian	47 56	49 00	Berg.
10	920	do	47 47	49 18	Berg and growler.
10	921	Ice patrol (M)	47 38	48 53	Berg.
10	922	do	47 30	48 32	Do.
10	923	do	47 39	48 23	Do.
10	924	do	47 39	48 05	Do.
10	925	do	47 38	47 50	Do.
10	926	do	47 13	49 08	Do.
10	927	do	47 14	49 06	Do.
10	928	do	47 16	49 11	Do.
10	929	do	47 16	49 17	Do.
10	930	do	47 12	49 22	Do.
11	931	Empress of France	46 49	51 55	Do.
11	932	do	47 04	49 46	Do.
11	933	do	47 17	49 37	Do.
11	934	do	47 14	49 22	Do.
11	935	do	47 19	49 05	Do.
11	936	Melmore Head	47 57	49 49	Do.
11	937	do	47 47	49 40	Do.
11	938	Cape Race (station)	39 56	61 38	Mast 60 feet long.
11	939	do	46 49	51 55	Berg.
11	940	do	46 57	50 06	Do.
11	941	do	47 13	49 46	Do.
11	942	do	47 17	49 37	Do.
11	943	do	47 14	49 22	Do.
11	944	do	47 19	49 04	Do.
11	945	do	47 47	49 40	Do.
11	946	do	47 57	49 49	Do.
11	947	Gracia	48 00 to 47 32	49 12 to 50 17	Several bergs and several growlers.
11	948	Cairnglen	48 09	50 05	Berg.
11	949	do	47 57	50 35	Do.
11	950	do	47 47	50 50	Do.
11	951	do	47 47	50 55	Do.
11	952	Ice patrol (M)	47 02	47 27	Do.
11	953	do	47 10	47 34	Do.
11	954	Canadian Commander	48 02	49 17	Do.
11	955	do	47 59	49 43	Do.
11	956	do	47 52	49 42	Do.
11	957	do	47 43	50 20	Do.
11	958	do	47 32	50 20	Do.
12	959	Metagama	46 43	52 06	Do.
12	960	do	46 48	52 05	Growler.
12	961	Canadian Explorer	46 52	52 00	Berg, same as 906.
13	962	Metagama	47 29	50 24	Berg.
13	963	Minnedosa	47 31	50 20	Do.
13	964	do	47 44	50 20	2 growlers.
13	965	Andania	46 50	52 03	Berg.
13	966	do	47 00	52 50	Do.
13	967	Svir	46 34	47 23	Berg and several growlers.
13	968	Minnedosa	47 46 to 48 01	50 02 to 49 25	8 bergs.
13	969	Andania	47 37	50 15	Berg.
13	970	do	47 31	50 00	Do.
13	971	do	47 36	49 33	Do.
13	972	do	47 43	50 16	Do.
13	973	do	47 56	50 00	Do.
13	974	Robilante	47 08	47 12	Do.
13	975	Andania	47 42	49 33	Do.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position: Latitude, north		Position: Longitude, west		Nature of ice or obstruction
			°	′	°	′	
June 13	976	Andania	47	44	49	35	Berg.
13	977	do	47	47	49	32	Do.
13	978	do	48	00	49	39	Do.
13	979	do	47	55	49	34	Do.
13	980	do	47	45	49	12	Do.
13	981	do	47	57	49	13	Do.
13	982	Cape Race (station)	47	40	48	43	Do.
14	983	do	46	49	51	58	Do.
14	984	do	47	00	52	00	Do.
15	985	Hilversum	47	10	46	50	Do.
15	986	Blairdam	47	23	49	59	Do.
15	987	do	47	33	49	48	Do.
15	988	do	47	38	48	58	3 bergs.
15	989	do	47	36	49	00	Berg.
15	990	do	47	41	49	00	Do.
15	991	do	47	33	48	35	Do.
15	992	Hilversum	47	35	48	16	Berg and growler.
15	993	Montrose	47	04	51	09	Growler.
15	994	do	47	05	52	08	3 growlers.
15	995	do	46	48	51	55	Berg.
15	996	do	46	54	52	48	Do.
16	997	Melita	47	27	50	55	Do.
16	998	do	46	43	52	25	Do.
16	999	Ascania	47	16	50	27	Do.
16	1000	Ice patrol	45	20	43	30	Dead whale, belly up.
16	1001	Transylvania	46	51	52	36	Berg and growler.
16	1002	do	46	50	52	53	Berg.
16	1003	do	46	58	52	23	Do.
16	1004	do	46	53	52	41	Do.
16	1005	Ascania	46	36	52	14	Do.
16	1006	Stavangerfjord	46	56	47	12	2 growlers.
16	1007	Cape Race (station)	46	46	52	27	2 bergs, 2 growlers.
17	1008	Drottningholm	45	47	46	28	Berg and growler.
17	1009	do	45	45	47	06	Berg.
17	1010	do	45	38	46	55	Berg and 2 growlers.
17	1011	Cape Race (station)	46	15	57	14	Spar.
17	1012	Pajala	48	31	51	23	Berg.
17	1013	Ariano	46	00	46	50	Berg and growlers, same as 954.
17	1014	do	45	49	47	20	Berg, same as 955.
17	1015	Bosworth	46	40	52	38	2 growlers.
17	1016	do	46	37	52	53	Small berg.
18	1017	Orca	46	34	52	34	Berg.
18	1018	do	46	33	52	32	2 growlers.
18	1019	Montnairn	46 35 to 47 19		53 00 to 50 09		5 bergs.
18	1020	Ice patrol (M)	45	47	46	41	Berg.
18	1021	do	45	54	46	42	Do.
18	1022	Delaware	46	00	48	00	Berg and numerous growlers.
18	1023	Holtby	45 57 to 46 00		47 36 to 47 14		Berg and 4 growlers.
18	1024	Cape Race (station)	48	31	51	23	Berg.
18	1025	do	46	51	52	29	Do.
18	1026	do	46	32	52	14	Berg and growler.
18	1027	Ice patrol	45	48	47	02	Do.
18	1028	do	45	53	47	22	5 growlers.
18	1029	do	45	48	47	34	Berg.
18	1030	Vestalia	46	32	45	54	Berg and 2 growlers.
18	1031	Calgaric	47	26	50	10	Berg.
18	1032	Holtby	46	23	45	55	Growlers.
18	1033	Pajala	48	07	51	42	Berg.
18	1034	do	47	14	51	42	Berg and several growlers.
18	1035	Vestalia	45	46	48	16	Growler.
18	1036	Cape Race (station)	48	12	51	42	Berg and several growlers.
18	1037	do	46	39	53	00	Berg.
19	1038	West Harcuvar	42	16	51	10	Gas and whistling buoy.
19	1039	Cape Race (station)	46	37	52	54	Berg.
19	1040	do	46	25	52	10	Do.
20	1041	do	46	34	52	53	Do.
20	1042	do	46	40	53	02	Do.
20	1043	Ala	47	25	50	06	Do.
20	1044	do	47	40	50	21	2 bergs.
20	1045	Strinda	47	39	50	39	2 bergs, several growlers.
20	1046	Antonia	46	34	52	52	Growler.
20	1047	do	47	07	50	28	Berg.

Table of ice and other obstructions—1927—Continued

Date	No.	Reported by—	Position				Nature of ice or obstruction
			Latitude, north		Longitude, west		
			°	′	°	′	
June 20	1048	Antonia	47	10	50	01	Berg.
20	1049	do	47	22	50	07	Do.
20	1050	do	47	14	49	44	Do.
21	1051	Canadian aviator	47	20	50	02	Do.
21	1052	Cape Rice (station)	47	31	49	58	Do.
21	1053	Svitriod	45	17	46	11	3 bergs.
21	1054	do	45	03	46	30	Small berg.
21	1055	Veendam	40	33	57	13	Light buoy (red).
21	1056	Bolingbroke	46	31	51	48	Growler.
21	1057	do	46	32	52	15	Berg.
22	1058	Montroyal	47	23	50	20	Do.
22	1059	Bolingbroke	47	20	50	05	Berg, same as 105.
22	1060	Cape Race (station)	48	37	50	24	2 bergs.
22	1061	Fannad Head	47	51	50	08	Berg.
22	1062	Cape Race (station)	46	39	53	02	Do.
23	1063	Caronia	46	04	51	52	Do.

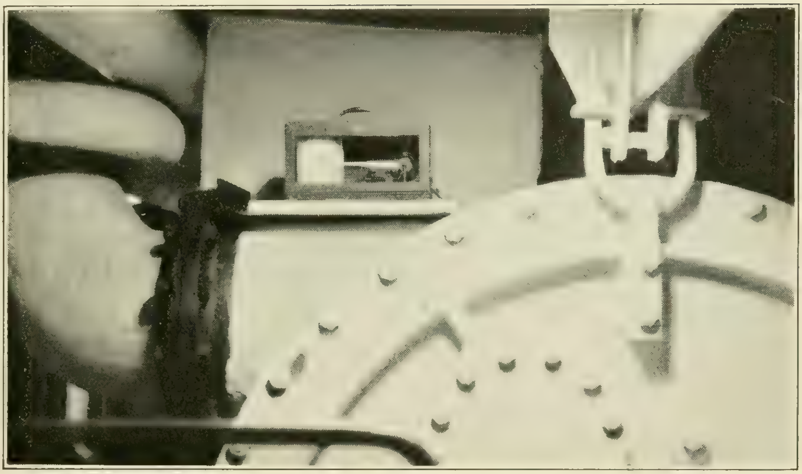

PLATE III.—THERE IS NOW INSTALLED IN THE CONDENSER INTAKE PIPE OF BOTH ICE PATROL SHIPS A SEA-WATER THERMOGRAPH, WHICH REGISTERS CONTINUOUSLY THE TEMPERATURE OF THE SURFACE LAYER THROUGH WHICH THE VESSEL PASSES

PLATE IV.—DIVINE SERVICES HELD ON THE "MODOC," APRIL 14, 1927, UPON THE FIFTEENTH ANNIVERSARY OF THE SINKING OF THE "TITANIC" WITH THE LOSS OF 1,571 LIVES FOLLOWING A COLLISION WITH AN ICEBERG

WEATHER

Following the arrangement of reports in former years, there is set forth under this section a description of the general weather conditions that were experienced during the ice patrol of 1927. The remarks, which are grouped according to months, are devoted to tracing the general behavior of the high and low pressure systems in the atmosphere as they traveled over the eastern United States and passed out to sea, across the ice regions. Accompanying the monthly remarks is a sketch showing the tracks of the more noteworthy disturbances, and also in other particular instances sketches have been appended. The weather diagram for each month gives at a glance the wind direction and force averaged for every 12 hours; the barograph curve; and the time and duration of fog and low visibility during the month. The geographical position, for which this is a meteorological record, although observed from the patrol ship cruising in the ice regions, can for all practical purposes and interpretations, be taken as latitude 43° 00′ N., longitude 50° 00′ W., the Tail of the Grand Banks. A general description of the two major types of weather which prevail in the ice regions, remarks on the structure of a storm, and iceberg forecasting by means of the weather are all contained in the ice patrol report for 1926 (Bull. No. 15), to which the reader's attention is invited.

MARCH

When the *Tampa* left Boston on March 22, a great mass of cold dry air was spreading east and southeast out of central Canada, across the North Atlantic States, the Maritime Provinces, and out on to the ocean. A center of low pressure retreated before this invasion leaving one vast area of high pressure enveloping the land and ocean to the northward of us. The *Tampa*, because of such a distribution of pressures, experienced continuous easterly winds on her passage to the ice regions. Along the southeastern border of this aforementioned air mass, from March 23 to 26, there traveled a low-pressure disturbance. It was first observed on the meteorological map for March 22 off the coast of the Carolinas, but after that it could not be followed so clearly, due to the scarcity of ship reports from this direction. Its path is shown fairly accurately, however, as track A on Figure 2, the center passing close to the *Tampa* on the morning of the 26th instant, when she was south of Sable Island. The first effects of this storm (a depression of the barograph, see fig. 1) were

observed when the center was about 420 miles from our position. It was then traveling at the approximate rate of 20 miles per hour. Soon after it had passed we got a rapid shift in the winds to a northwesterly direction, which increased three hours later to force 10 of the Beaufort scale.

A second large anticyclone spread across the country and out to sea from the 27th to the close of the month, thus furnishing the

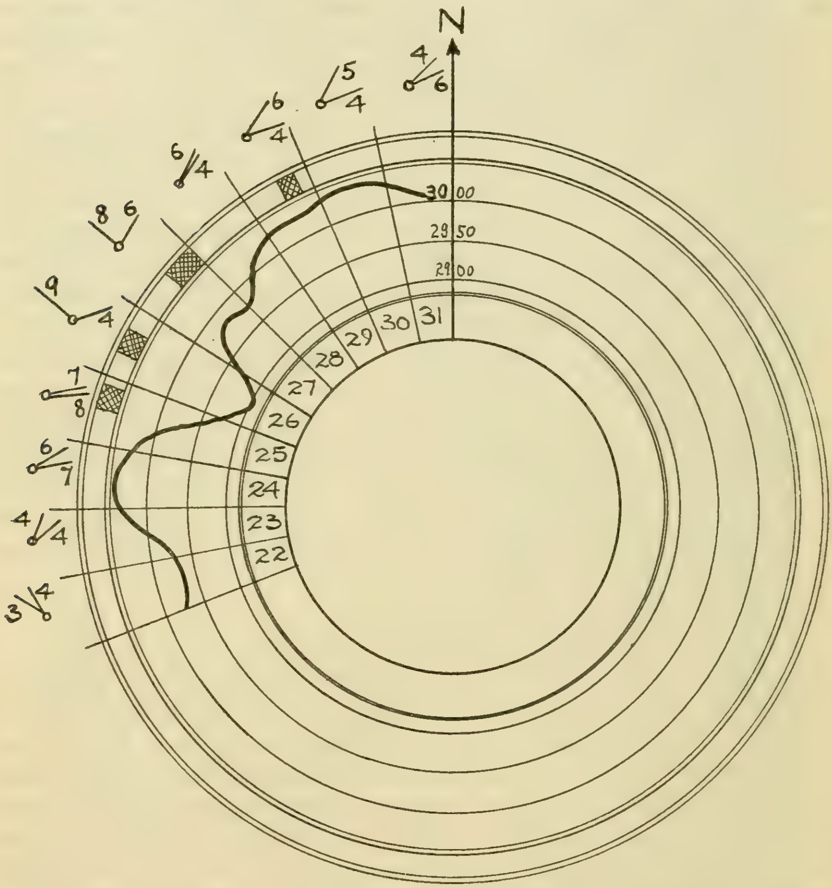

FIG. 1.—March weather diagram. The inner circle gives the day of the month; the next band out contains the record of atmospheric pressure; the next outer one indicates the degree of visibility (crosshatched areas represent low visibility and black areas duration of fog); the outer margin shows the average direction and force of the wind, per 12-hour periods, noon and midnight

Grand Banks with prevailing northeasterly winds and generally fair weather for the end of the month.

Another disturbance from March 29 to April 3, took a path shown as track B on Figure 2. It followed a course farther north than most storms, due to an interposing anticyclone that was lying over the Atlantic States at the time. This situation tended to keep it at a distance from our vicinity, yet on reaching a point near St. Johns, Newfoundland, the depression deepened and thus intensifying, for

about eight hours, April 2, set up a considerable indraught of southerly winds. This brought heavy rains and some low visibility for a

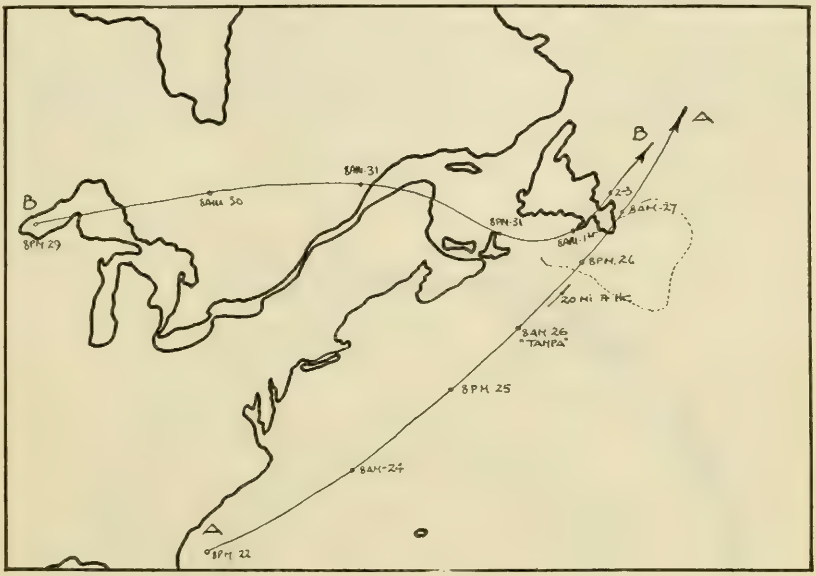

FIG. 2.—March cyclone tracks

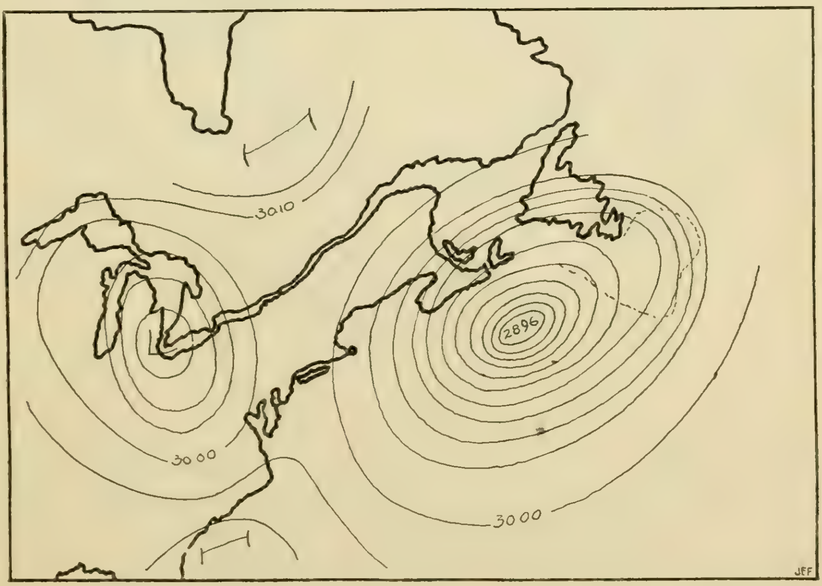

FIG. 3.—Isobaric map for 8 a. m. March 26, 1927. The center of the disturbance, traveling at the rate of 20 miles per hour, passed directly over the position of the "Tampa," then just south of Sable Island (see p. 33)

few hours, to the relatively cold Grand Banks regions. The weather for March, 1927, was much better than that for the same month in 1926. We experienced practically no fog and only 17 per cent hours

of low visibility in the nine days of March which we were at sea. There were four days out of the nine, however, during which the wind attained gale force.

APRIL

Disturbance C, Figure 5, was observed south of Chicago the evening of April 1, from thence it moved easterly, passing out to sea on the 3d instant. Several steamship reports from along the 40th

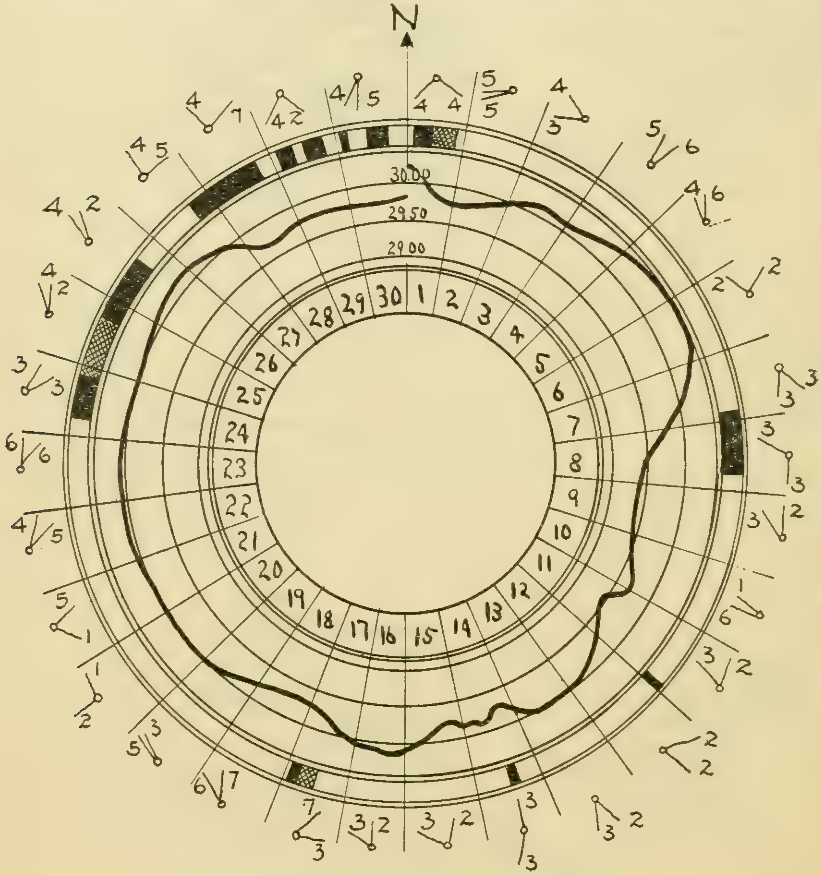

FIG. 4.—April weather diagram

parallel permitted us to locate this center on the 4th, then between our position and Bermuda. It was still moving in an easterly direction, and probably prevented from following the usual northeasterly course by a large anticyclone centered over the Gulf of St. Lawrence. The presence of this "high" moreover undoubtedly saved us from the discomforts of passing through another severe storm similar to the one experienced last month. The steamship *Majestic*, 200 miles southwest of our position on April 4, reported a very rough sea and a northeasterly gale. The path of this depression is shown as track C, Figure 5.

April 3 a new depression put in appearance over Iowa and during the next four days crossed the country, as shown on Figure 5, track D. An interesting feature in connection with this cyclone is that it brought to the Newfoundland region, an area of low pressure which prevailed there for the succeeding 10 days. In fact, the general distribution of atmospheric pressure over the eastern United States and out over the ocean including the ice regions, did not materially alter for the nine-day period, April 7 to 16. Such a stagnation in the characteristic progress of "highs" and "lows" is a rare phenomenon at this time of the year. The foregoing general conditions are shown on Figure 6. The patrol, cruising on the Grand Banks during this period, enjoyed excellent weather conditions.

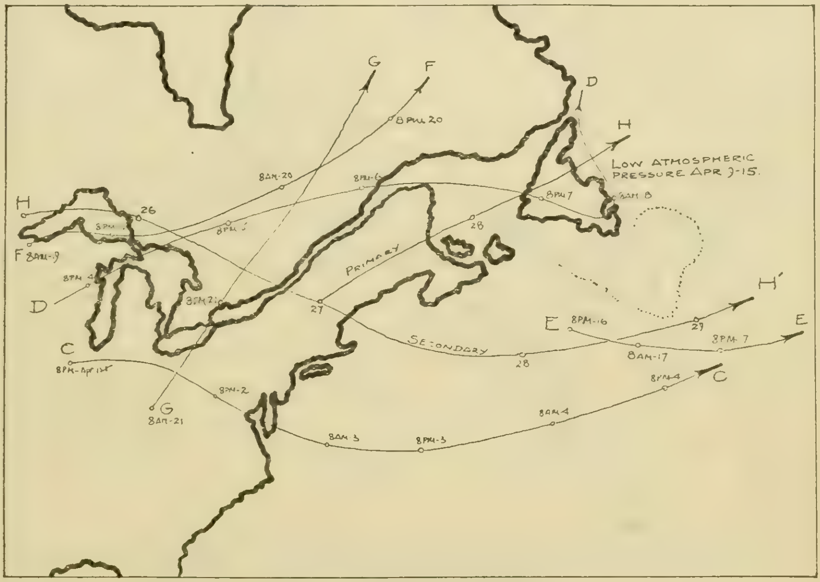

FIG. 5.—April cyclone tracks

An interesting meteorological phenomenon took place April 16, when in a locality about 150 miles southeast of Sable Island there was witnessed the development of a disturbance (cyclone) of restricted but considerable intensity. It traveled almost due east along the northern edge of the Gulf Stream and the forty-second parallel, and on April 17, passed about 140 miles south of the ice patrol ship. We experienced easterly winds of increasing strength early the morning of the 17th, which gradually backed to north and attained gale force by nightfall. The lowest barometer reading at this time was 29.70, clearly indicating that the *Modoc* was in the cold northern sector of the storm, the center apparently passing at the rate of 15 to 20 knots per hour. The strongest wind was from the north and north-northwest, and some snow fell during the night hours. Conditions indi-

cated that the depression was deepening and intensifying as it traveled eastward. The winds backed still further during the 18th and finally later in the day, gradually abated in force as the disturbance moved out into the North Atlantic and all influence had disappeared. Track E, Figure 5, is an excellent example of the birth of a cyclonic vortex in the atmosphere, probably materially aided by the presence of warm and cold masses of water along the southern border of the Nova Scotian continental shelf. This particular cyclone had its birth over the northern edge of the warm and cold water where the current curves up in the great oceanic bight west of the Grand Banks. Track E is an example of developments that may take place in the atmos-

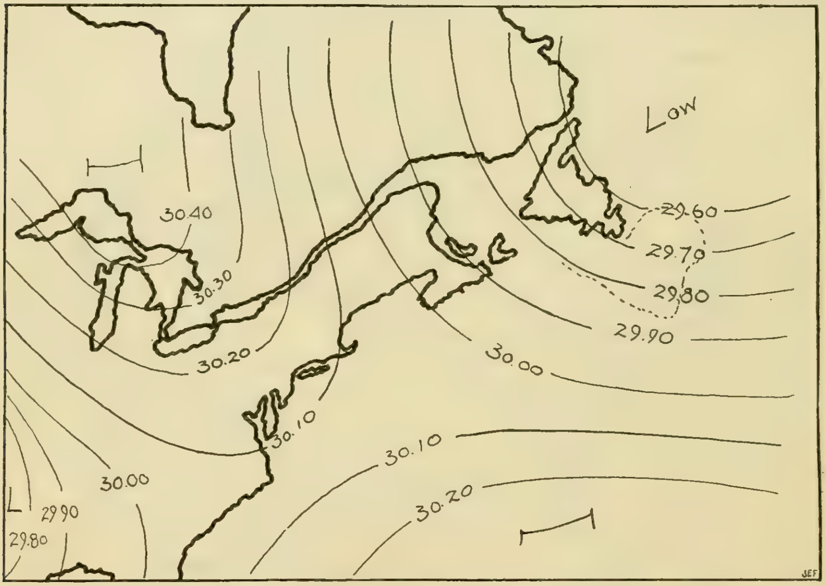

FIG. 6.—The general distribution of atmospheric pressure from April 7–16, during the nine days of which there was an unseasonable stagnation in the movement of "highs" and "lows"

phere over an ocean but where due to the scantiness of data, winds sometimes even of considerable intensity can not be explained by reference to the generalized weather map.

The distribution of pressure following the events described above took the form of a huge high pressure area extending from Newfoundland southward over the Atlantic States to Florida. This mass of air, however, gradually shrank in extent until on the 19th it centered over the Carolinas and by the 20th it had retreated completely to join the more or less prevailing "high" in the direction of Bermuda.

An expansive area of low pressure which had lain motionless since April 7 (for a period of about two weeks) over the Southwestern States, began to move about the 20th and simultaneously with the removal of the high pressure described in the preceding paragraph. Its track F, Figure 5, from April 18 to 20, is shown crossing northward to Lak

Superior and thence eastward, later curving to the left, and finally occluding in the direction of Labrador. Another depression moved from near Cincinnati, Ohio, where it had first formed, north-northeastward toward Labrador, and finally off the map.

It was noted this month that there appeared to be an excess of air over North America with the "highs" pushing the low-pressure centers to the northward and easily filling them up. The tendency for the atmospheric high pressure, especially over Nova Scotia and Newfoundland during April and the latter part of March, resulted in an abnormal percentage of northeasterly and easterly winds for the Grand Banks region. This condition was doubtless the underlying factor responsible for the notable westerly positions of the ice south of Newfoundland during April. A depression followed track G, on Figure 5, from 8 a. m. the 21st until 8 p. m. the 23d, when it disappeared from the meteorological map in the region of Labrador.

The next depression of consequence was centered just west of Lake Superior the morning of the 25th. It had advanced to Lake Huron by the morning of the 26th, and from thence it curved to the northeastward and finally on the 27th assumed an elongated shape covering an area from Quebec southward of Nantucket. (See track H, Fig. 5.) A small portion of this area apparently broke away from the main system and drifted southeastward and thence eastward, passing south of the Grand Banks on the 28th instant. We experienced fresh easterly winds in consequence and more fog than at any period this season. Newfoundland and the Grand Banks vicinity continued to have low atmospheric pressure for the remainder of the month.

Summing up, we are particularly impressed with the prevalence of easterly and northerly winds this year. This was due primarily to an excess of air which persisted over the Canadian Maritime Provinces and Newfoundland, where in normal season, low pressure usually prevails. This distribution of pressure and the consequent system of winds tended to hold the field ice and bergs nearer the continental slope than they normally would otherwise have drifted. There were, however, only two days, the 17th and 18th, upon which the wind attained gale force. Fog was present 16 per cent of the month and low visibility and fog 22 per cent.

MAY

The first week in May was characterized by a relatively large number, and frequency, of centers of low and high pressure. Families of cyclones, four and five in number, appeared on the meteorological map at time of observation instead of two or three as is normally the case, and as these several centers drifted across the ice regions the patrol experienced unsettled and changeable weather. The *Modoc*, returning to the patrol on the 9th instant, stated that similar weather condi-

tions were experienced in Halifax; first a warm day followed by one which was cool.

An unusually deep atmospheric depression was observed on the meteorological chart for the morning of May 9. The lowest barometer reading was recorded in Nebraska but the attending low-pressure system spread over a relatively large area of the central United States. This "low" moved eastward very slowly and assumed various shapes

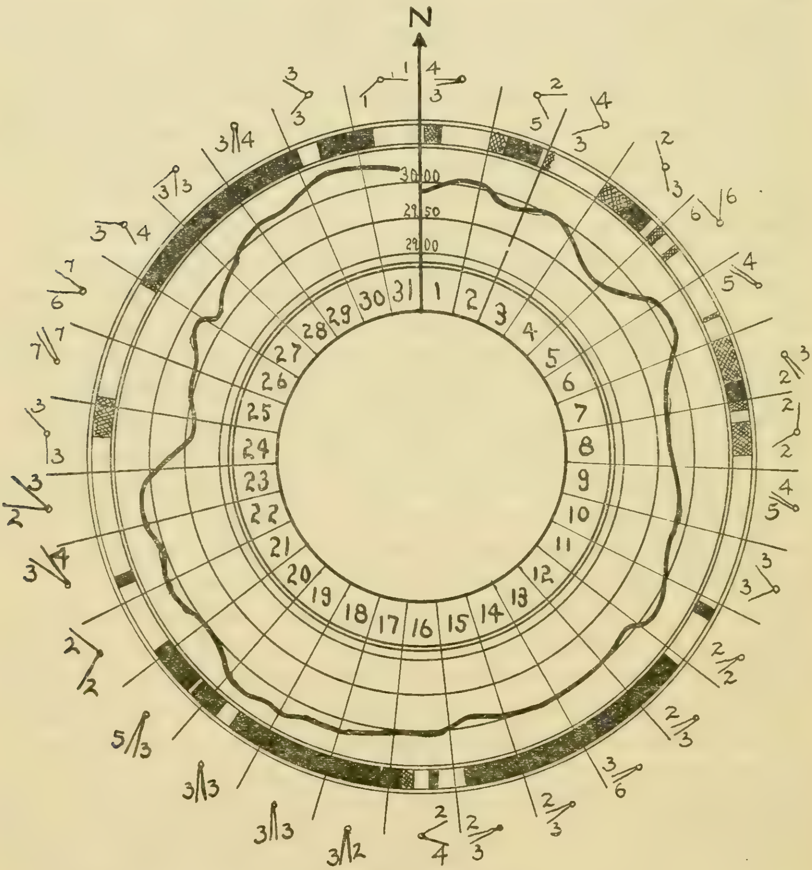

FIG. 7.—May weather diagram

and positions but remained at all times over the continent. The period May 11 to 20, consequently, was characterized by general low atmospheric pressure over the United States east of the Mississippi River Valley and extended eastward over the Maritime Provinces and Newfoundland. (Fig. 9.) These summer-time conditions brought southerly winds, rain, and a protracted spell of wet weather to the northeastern part of the country, and the ice regions coming again under prevailing southwesterly winds received the first prolonged period of fog for the season. We had almost continuous fog and low

visibility in the cold waters around the Grand Banks from May 11 to 20. (See Weather diagram, Fig. 7.)

FIG. 8.—May cyclone tracks

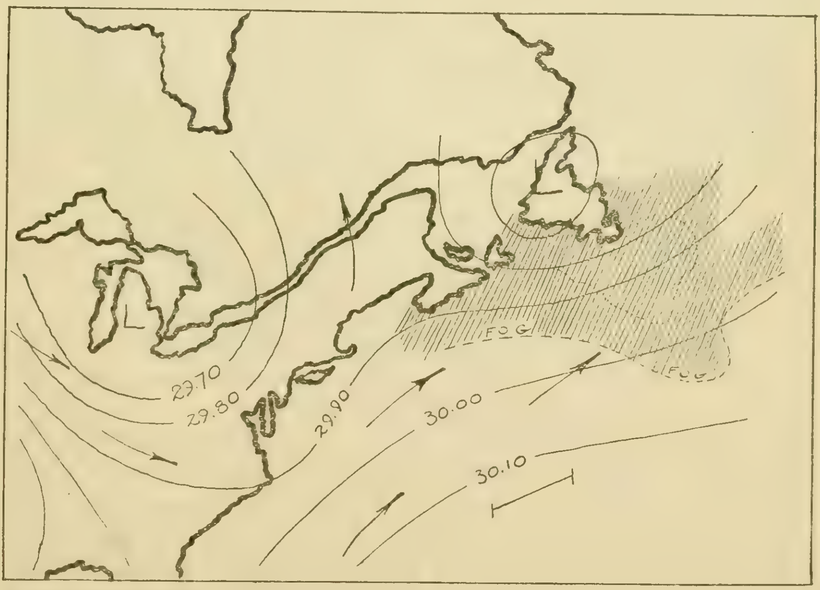

FIG. 9.—The distribution of atmospheric pressure May 11–17; a type of distribution that is common during the warmer months of the year. During this period of seven days the relatively cold waters of the Nova Scotian and Newfoundland Banks were enveloped in thick fog. The normal fog area under such conditions is shown as a shaded area on the figure

The meteorological map for 8 a. m., May 21 recorded the first material change in pressure conditions since the 11th instant. The pressure increased very rapidly over the eastern half of the United

States and a ridge in the atmosphere extended southward from Hudson Bay to Bermuda. New meteorological conditions came not as a surprise to the patrol as we had experienced stormy weather all day of the 20th which pointed toward a forthcoming change. Early the morning of the 21st, the fog rolled away before a gentle northwesterly breeze, revealing in all directions a hard, clear cut horizon. This was the patrol's first opportunity to scout for ice since May 9, 12 days previous. High pressure and clear weather prevailed from May 21 to May 27, upon the latter day of which fog and mist again shut in.

A disturbance of unusual intensity for this time of season marked the days of the 25th and 26th. The storm developed from a moderate depression over Montreal on the morning of May 22. The next day it moved eastward to the Gulf of St. Lawrence and deepened to a minimum of 29.66 recorded at Harrington, Quebec. It finally paused in its northeasterly progress because Cape Race and ships to the eastward on the 24th instant reported pressures of 29.35 and 29.29. The patrol ship, 150 miles to the southward, recorded a pressure of 29.50, but no stormy conditions existed and the winds continued light from the westward. Early the morning of the 25th, however, our barograph began to rise rapidly and the wind increased correspondingly in force from a northwesterly direction. At 8 a. m. it was blowing with gale force and a ship northeast of Cape Race, about 300 miles from the patrol, reported a barometer reading of 28.60. Situated on the rear of this disturbance we experienced one of the strongest gales and roughest seas for the season of 1927. Conditions slowly grew better on the 26th, and the wind shifted to light southeasterly airs with low visibility ensuing. That the stormy conditions of the past few days had not ceased was apparent by glancing at the meteorological map for 8 p. m. of the 26th where we found depicted another well-developed but less deep depression than that of the 25th. It became centered east of Newfoundland where it remained from the 24th until the 26th and then another equally well-developed depression arrived from the westward and remained in the vicinity of Newfoundland until the 29th. It was plain to see that for some cause the atmosphere from May 26 to 31 had become unseasonably agitated.

The outstanding feature for the month was the changeable weather during the first nine days, followed by two weeks stagnation of "highs" and "lows," providing for the Grand Banks almost continuous fog and summer-time directions of wind. The latter part of the month was featured by increased activity in the atmosphere as high and low pressure centers followed each other across the map. We experienced only two days upon which the wind blew with gale force and we experienced 43 per cent hours of fog and 55 per cent hours of fog and low visibility.

JUNE

On June 1 a low pressure centered near Nova Scotia elongated its shape to the eastward causing easterly winds to blow around the Grand Banks. As this depression moved northeastward the wind hauled to the southward, but the "low" hovered in the vicinity of Newfoundland until the 4th instant, when it was displaced by a large anticyclone. The fog caused by the southerly winds during the first

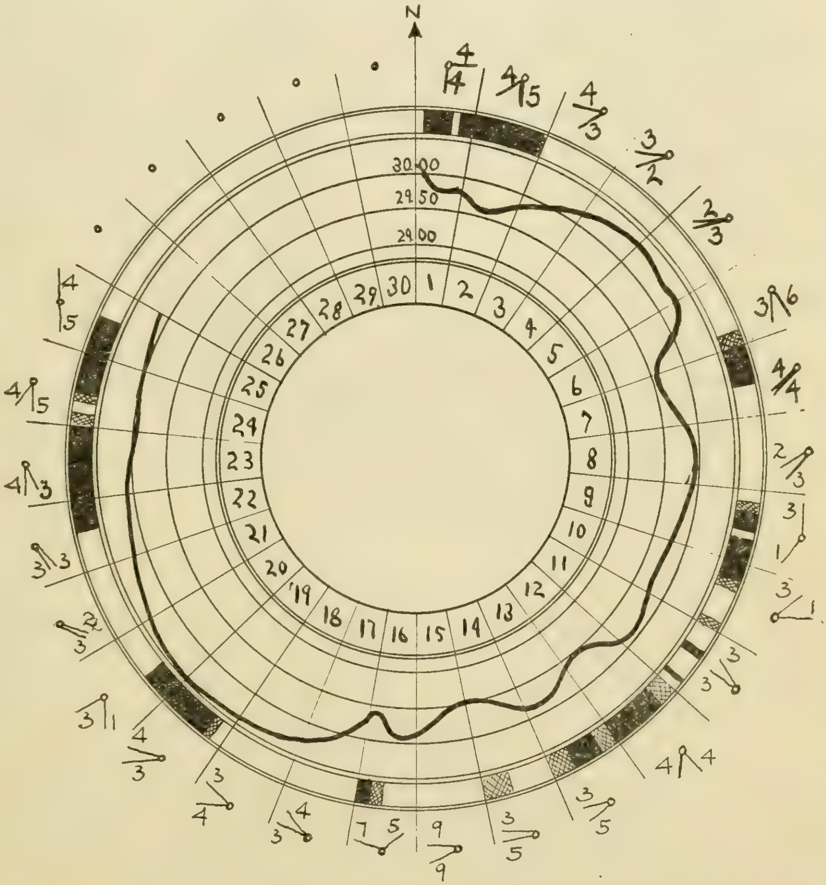

Fig. 10.—June weather diagram

three days in June lifted on the 4th, giving the patrol an opportunity to scout for ice during the succeeding four days. It was unusually clear June 7, when the anticyclone completely surrounded the Grand Banks, and on that day we sighted several bergs the exceptionally long distance of 20 miles away.

A disturbance was noticed on the meteorological map for June 3, it being centered over the Mississippi River Valley, and its path across the country and over the ice regions is shown on Figure 11, marked

"A." This "low" was of more than ordinary significance in that its passage was simultaneous with the stranding of a French fishing vessel on the southern coast of Newfoundland, 3 miles west of Cape Race. Its untimely appearance unfortunately caused strong southerly winds which quickly broke this vessel up on the rocky shore, thus making her a total loss. The passing of this storm brought the wind around to the westward and we again enjoyed clear visibility.

It was apparent from the examination of the file of daily meteorological maps that there was tendency for low pressure to spread over a large portion of the northern tier of the United States. In fact a depression stretched all the way across the northern part of the country with a "high" resting over the ocean in the region of Bermuda.

FIG. 11.—June cyclone tracks

Thus the stage was all set for the normal summer-time distribution of pressure, prevailing southerly winds, and much fogginess. Such conditions actually persisted from the 7th to the 14th instant, a situation similar to that which prevailed May 11 to 17 (see p. 41). On the 12th instant a high-pressure area was observed to be accumulating over the western plains and consequently we looked forward to a respite of clear weather.

The *Modoc* on June 13 was called eastward to the fortieth meridian, nearly mid-Atlantic, by a medical case and returning to the Grand Banks encountered a strong westerly gale. On the 14th the wind blew so forcibly that it was necessary to reduce speed to bare steerage-way. The great wind velocity was due to a disturbance northeast of Newfoundland, which deepened and intensified. No sooner had

the gale of the 14th abated than another disturbance was located about 250 miles south-southeast of Sable Island. It had been lost on the Weather Bureau's synoptic map, when it passed out to sea off the Virginia coast the 15th, but the ice patrol was able to plot its position quite accurately from a number of ship reports scattered over a large area. The winds accompanying this disturbance backed through the northeast, showing that the storm was passing to the southward of us and by the 17th the wind had weakened to a moderate breeze from the northwest, with fine weather again. The path of the cyclone is shown as track B on the weather map for the month. (See fig. 11.)

An anticyclone of expansive proportions followed closely in the rear of this disturbance, bringing northwesterly winds, high pressure and fine weather, the 18th, 19th, and 20th, but on the 21st, and 22d a general lowering of the barograph ushered in summer-time conditions, a shift of wind to the southern quadrant, and plenty of fog for the ice regions.

The first week of June was characterized by a large anticyclone and clear weather favorable for ice scouting. The second week low pressure over northeastern North America and high pressure in the region of Bermuda, gave southerly winds to the Grand Bank and much fog. The third and last week the patrol was in the ice regions we experienced two disturbances, one of which followed a track south of the Banks. There were two days during the month when the wind attained gale force. There was 33 per cent hours of fog and 43 per cent hours of fog and low visibility.

SUMMARY

The season's summary reveals the following facts: Probably the most outstanding meteorological event of March, at least for the patrol, was the passage of a severe storm center directly across the position of the *Tampa* southeast of Sable Island; the barometer recording a minimum of 28.96 inches. April 7 to 16 witnessed a general stagnation in the usual march of the "highs" and "lows," but the most important weather characteristic of April was the prevalence of anticyclonic conditions over Nova Scotia and Newfoundland, resulting in an abnormal percentage of easterly and northeasterly winds. May saw families of cyclones, and changeable weather up until the 8th, followed by a period of 11 days when a summer-time distribution of atmospheric pressure brought the first really long spell of fog. Gales and strong winds ushered out the month. June 7 to 14 there was a resumption of low pressure over North America and a return of the blanket of fog to the cold waters around the Grand Bank. The normal monthly percentages of fog based on 7 consecutive years of patrol records are: April, 24 per cent; May, 28 per cent; and June, 38 per cent. There was only one-half the usual amount of fog during

April this year; May, however, there was about double the normal amount, and June proved to be just about normal. A table showing monthly records of fog, fog and low visibility, gales, and calms for the 1927 ice season is shown below:

Month	Percentage (hours)		Gales (number of days)	Winds (average force)	Calms (number)[1]
	Fog	Low visibility			
April	16	22	3	3.6	0
May	43	55	2	3.3	0
June	33	43	2	3.7	0

[1] Based on 12-hour periods.

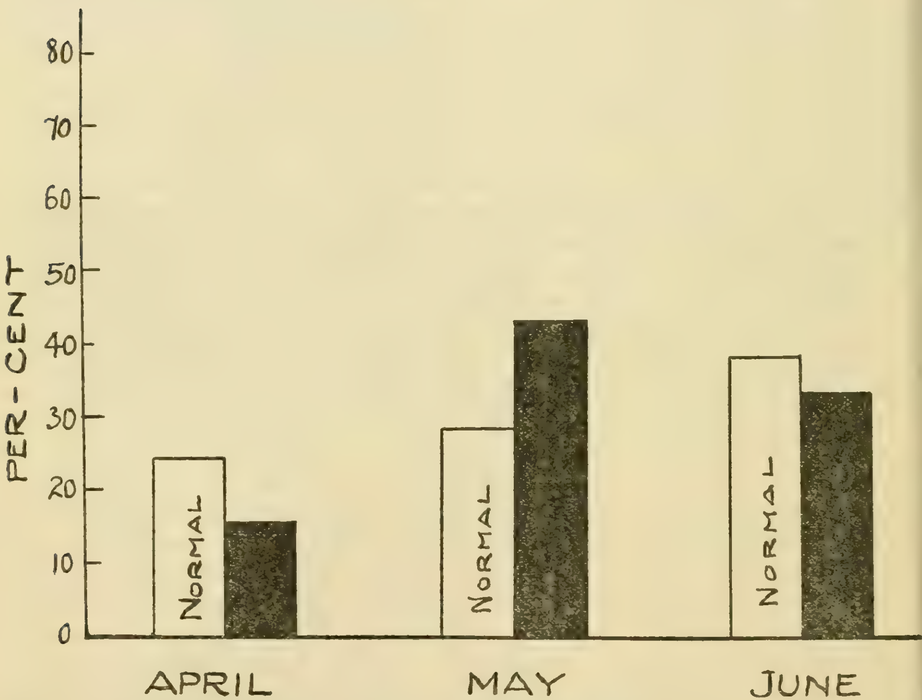

FIG. 12.—The monthly percentages of fog around the tail of the Grand Bank during the ice season of 1927, and as compared with normal

Figure 12 shows the monthly percentages of fog which was observed by the patrol around the Tail of the Grand Banks during the ice season of 1927. The percentage of fog that envelops the ice regions is always a subject of vital interest, since, obviously, fog and low visibility greatly magnify the danger of collision with icebergs.

COOPERATION WITH THE UNITED STATES WEATHER BUREAU

Following the procedure on previous patrols a meteorological map was constructed twice daily on board ship, the data being obtained from the general synoptic reports broadcasted by the United States

Weather Bureau from the naval radio station at Arlington at 10 a. m. and 10 p. m. Occasionally the weather experienced by the patrol vessel did not accord with the Weather Bureau's data when plotted on a base map. In such cases it was necessary to collect reports from as many ships as possible and well scattered within a radius of 500 miles of our position. This work often revealed the presence of disturbances that had formed or developed over the sea, the position of these storms being unknown to the Weather Bureau, at least when it had sent out its routine data.

Twice daily, as in former years, at 8 a. m. and 8 p. m., a report was dispatched to the United States Weather Bureau, Washington, D. C., and at the end of each cruise a more detailed report was forwarded by mail to the Washington weather officials.

ICE FORECASTING BY MEANS OF THE WEATHER

Last year's annual report (Bull. No. 15, pp. 45–48) contained an account of a scientific investigation carried on at Harvard University

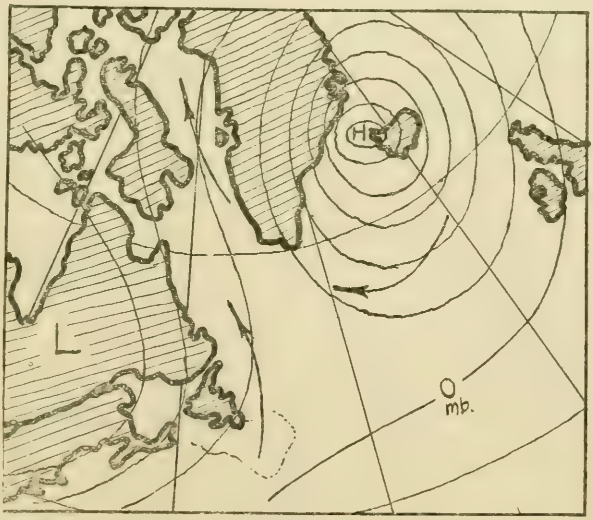

FIG. 13.—The anomaly of atmospheric pressure over the northwestern North Atlantic for the month of October, 1926. Isobars drawn every 2 millibars. Conditions when reflected the following spring spell less ice than normal

and later at the British Meteorological Office, London, into the possible relationship, between the varying amounts of Arctic ice from year to year and meteorological events occurring in the northern regions some months previously. It appears logical to believe that the prevailing direction of winds over the Labrador-Greenland region, when expressed in terms of departures from normal, and considered in monthly periods, would be reflected sometime later in the variations from normal in the amounts of ice. It has been found best throughout the investigation to work with differences from means, and this fact should be kept in mind by the reader.

The first factor, consisting of the atmospheric pressure differences between two points taken across the line of drift of the ice on its journey to the southward, is being furnished by the United States Weather

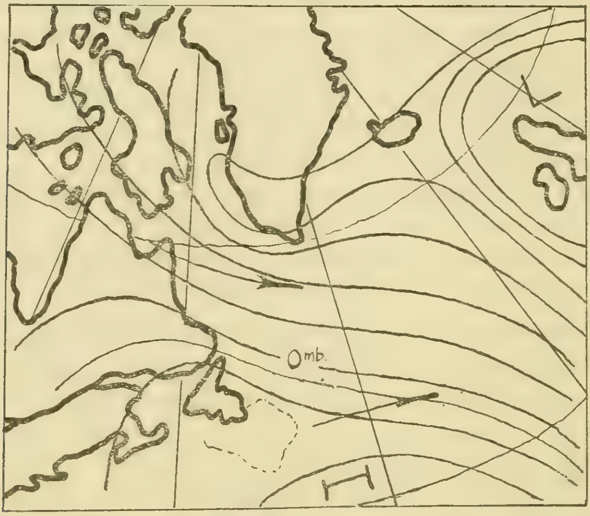

FIG. 14.—November, 1926, anomaly of atmospheric pressure. Conditions when reflected the following spring indicate more ice than normal

Bureau in the form of monthly mean pressure records from meteorological stations scattered around the shores of the North Atlantic. Observation points even in Greenland are now connected with the

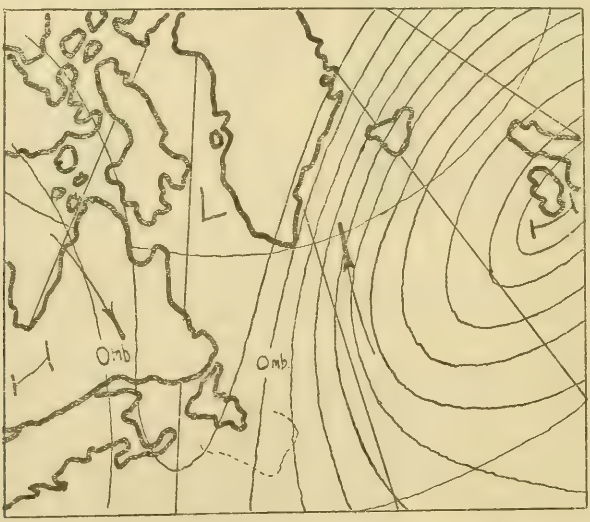

FIG. 15.—December, 1926, anomaly of atmospheric pressure. Conditions when reflected the following spring indicate a normal ice season

outside world by radio, a fact of great importance to the success of this particular ice forecasting problem. Maps showing the anomaly isobars, one map for each of the months, October, 1926, to March,

1927 (see figs. 13 to 18, inclusive), will give the reader a pretty fair picture of events leading up to the ice season of 1927. It is plain to

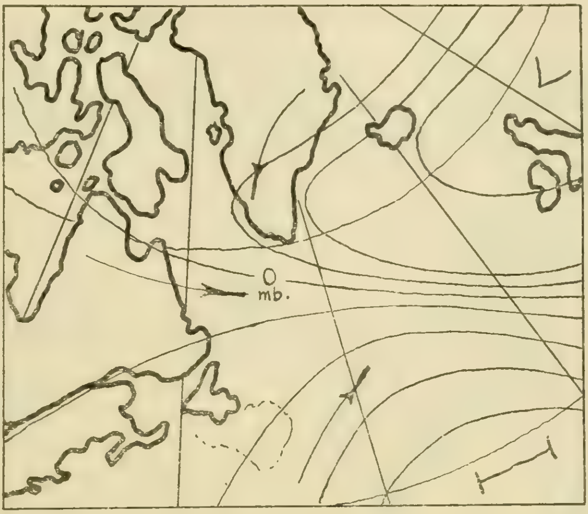

FIG. 16.—January, 1927, anomaly of atmospheric pressure. Conditions when reflected the following spring indicate more ice than normal

see, for example, that during October, 1926, meteorological conditions were less favorable than they usually are for Arctic ice to drift southward into the Atlantic. December, 1926, the winds were more

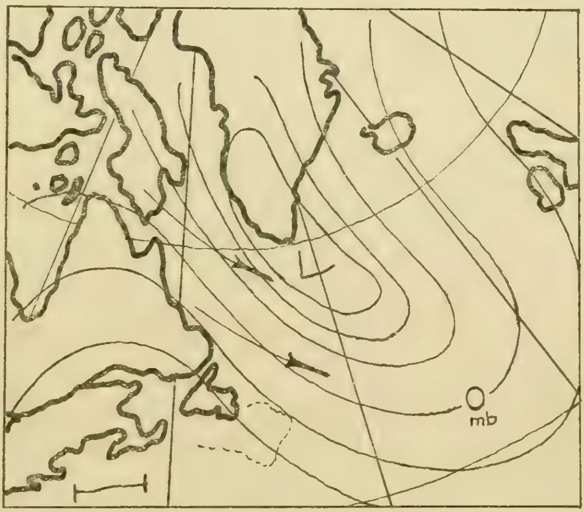

FIG. 17.—February, 1927, anomaly of atmospheric pressure. Conditions when reflected the following spring indicate more ice than normal

or less neutral, but November, January, February, and March were more favorable than ordinarily to a greater abundance of ice appearing in the spring of 1927 than is normal.

A more accurate method of measuring the value of the meteorological factor was found by our investigation to be an equation

$$\text{Bergs} = 4.8 - 0.08(c) - 0.12(d)$$

where the number of bergs is expressed as a value 0–10; c represents the pressure difference in millibars between Belle Isle and Ivigtut; d represents the pressure difference between Stykkisholm and Bergen. (For details of the values see Bull. No. 15, p. 48.)

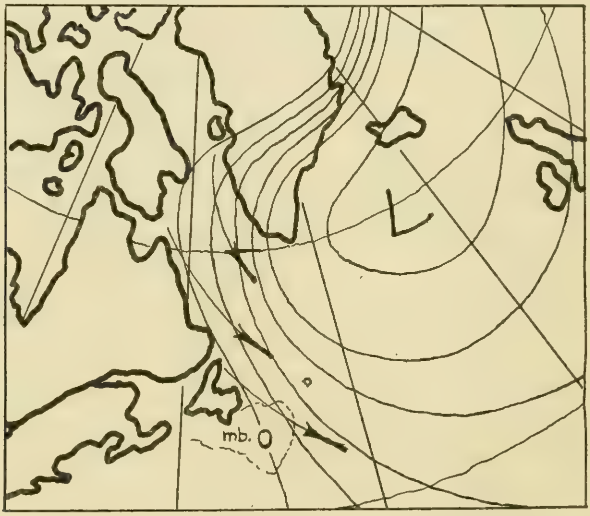

FIG. 18.—March, 1927, anomaly of atmospheric pressure. Conditions when reflected in the spring spell more ice than normal

A forecast was made in a letter, March 11, 1927, to the chairman of ice patrol board, that about 396 bergs would drift south of Newfoundland during 1927, or field ice and bergs somewhat in excess of that during a normal year. As a matter of fact we now know after a careful check that the number of bergs for the danger season, March to July, was 367, and about 390 for the entire year, and thus the forecast was quite accurate. (See iceberg table, p. 16.) The number of bergs may vary within wide limits; for example, in 1912 there were 1,200 and in 1924 only 11. The forecast in 1927 was purposely kept from publication because it is desired to test the work with a few more trials, but it all is most encouraging and the service will be continued for 1928.

DEPTH SURVEY CARRIED OUT WITH THE SONIC DEPTH FINDER

Work was continued during 1927 with that part of the scientific program which related to surveying the bottom contour in the ice regions whenever opportunity offered. The work really has two principal objects, (1) to contribute more cartographical information than is now on record of these little frequented regions, and (2) to learn more regarding the currents through a more detailed knowledge of the sea floor, because as we well know, the configuration of a sea basin casts an important influence upon the moving masses in it.

The sonic depth finder apparatus was operated this season by a member of the Coast Guard, a chief petty officer, who received an eight weeks' course of instruction at the Navy sound school, United States Navy submarine base, New London, Conn. The apparatus functioned quite satisfactorily throughout the entire patrol.

The calculations of the time interval used in multiplication to obtain the depth, were facilitated by a graphic means of division, the curves being constructed of a scale sufficiently large to permit interpolation to 2 in the third decimal place of the time factor. The velocity of sound in the water column, at the particular spot, was obtained by referring to the chart that was especially constructed for this region last year (Bull. No. 15, fig. 9, p. 49), in which corrections have been made for the influences arising because of pressure, salinity, and temperature. The geographical positions of the sounding were not accepted until they had been tested by several astronomical sights, and frequently supplemented by radio compass bearings from Cape Race.

There was a total of 435 soundings recorded this year which range from as shallow as 30 fathoms to as deep as 2,312 fathoms. A report and record of the data has been submitted to both the United States Hydrographic Office and the United States Coast and Geodetic Survey, in order that revision may be made in the proper charts.

One of the most important advantages that has been gained from the sonic apparatus by the patrol has been of a navigational nature. The distribution of the ice, and consequently the activities of the patrol, take place in general along the Atlantic faces of the Grand Bank, a region notorious for its fogs. In consequence the patrol vessels experience considerable difficulty in obtaining frequent and accurate astronomical "fixes." The depth of water, rapidly and easily taken by means of the sonic apparatus, however, quickly locates our distance in or out with respect to the bottom grade, while a radio bearing from the only station in the ice regions, Cape Race, fixes our position along the slope.

ICE OBSERVATION

It has been customary for a number of years to devote a section of the annual report to remarks on the behavior and distribution, in time and place, of all Arctic ice south of Newfoundland (the forty-eighth parallel of latitude). A certain amount of statistical work on this subject in addition to current reports, has been carried on by the ice patrol, especially that covering the amount of ice from year to year and from month to month. A complete report for those students interested in this aspect of the subject is contained in Ice Patrol Bulletin No. 15 (for 1926), pages 75 to 77. The ice observation for the season 1927 follows:

JANUARY

There was a total of four icebergs reported by steamers for the month of January. All of these bergs were distributed along a line

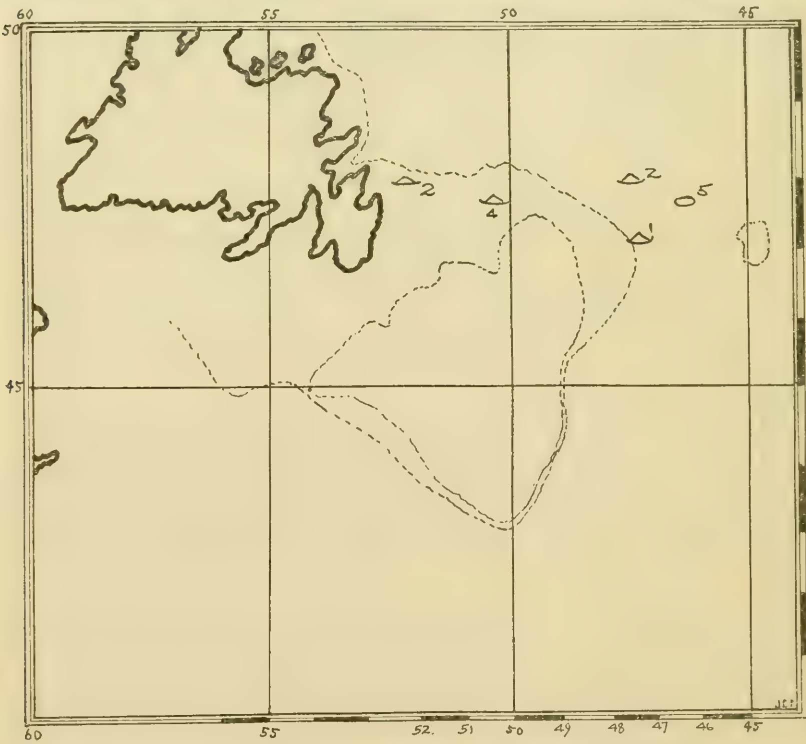

FIG. 19.—January ice map. The position of the first Arctic ice for the year 1927. △ represents an iceberg. There were four bergs south of the forty-eighth parallel during the month

between St. Johns, Newfoundland, and Flemish Cap. This information was obtained from Cape Race radio station by the ice patrol ship upon its initial arrival in the ice regions. Conditions were considered average, as a normal January records three bergs. (See Iceberg Tables pp. 75–76, Bull. No. 15.)

FEBRUARY

Field ice put in its first appearance on February 10, when reported in a position between Cape Race and Sable Island. This ice was doubtless of St. Lawrence origin, it having been blown offshore to the outer edge of the shelf. The first flat ice of Arctic origin was sighted on the 19th instant, from latitude 48° 20′ longitude 50° 00′ to latitude 47° 50′ longitude 50° 05′, the extreme northern part of the Bank, about 100 miles due east of St. Johns. There were seven other reports relating to the position of field ice during the month,

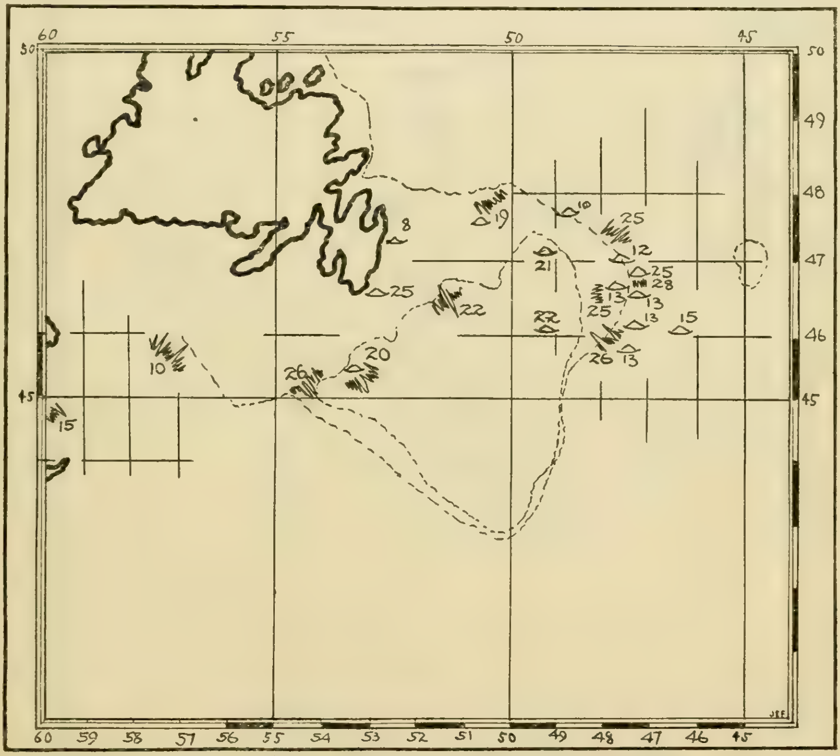

FIG. 20.—February ice map. represents field ice. There was a total of 10 bergs south of the forty-eighth parallel during the month

the southernmost field being found in latitude 46° 00′, on the eastern slope of the Grand Banks. This southerly position indicated an invasion of nearly 120 miles, all which took place during the latter part of the month. A total of 10 separate and distinct bergs, it is estimated, drifted south of the forty-eighth parallel during February; the most of these moved south along the usual path parallel with the eastern slope of the Grand Bank. There were two exceptions when two bergs drifted toward Cape Race close in near the shore. The southernmost berg during February was reported on the 13th instant,

then just below the forty-sixth parallel between Flemish Cap and the Grand Banks. The normal number of bergs for February is 10, just what was observed.

MARCH

There was a total of 7 field-ice reports and 38 reports of icebergs received during the month, some of which, of course, referred to the same ice. No field ice, however, was sighted south of the forty-sixth parallel, a fact which showed the ice had not increased in abundance

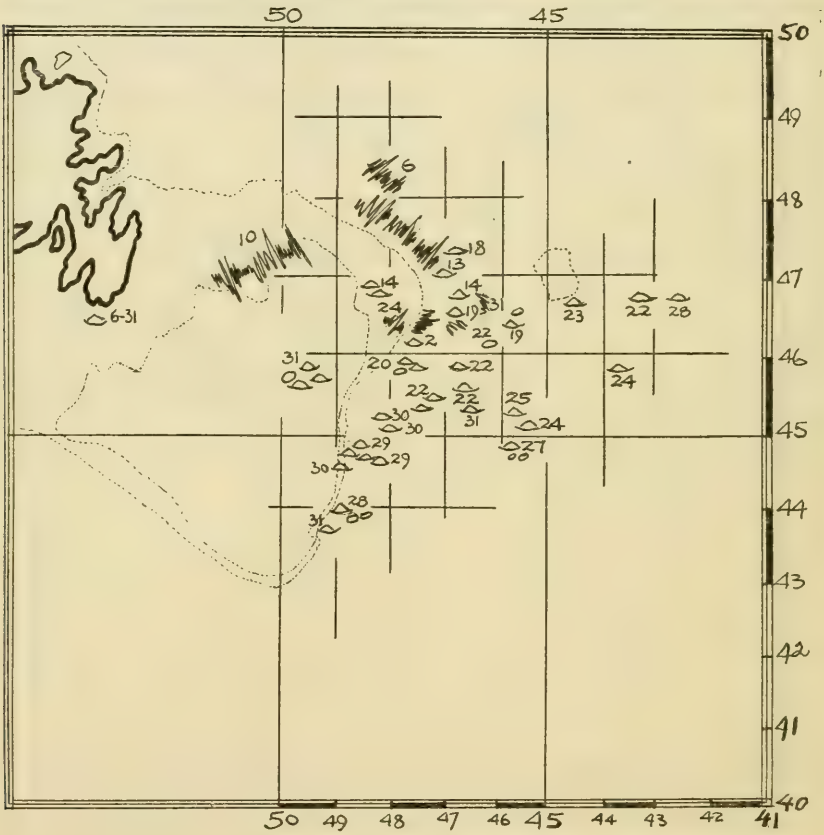

FIG. 21.—March ice map. There were 26 bergs south of the forty-eighth parallel during the month

sufficient to extend its boundary southward of a point observed in February. About half of the bergs drifted southeastward between Flemish Cap and the Grand Banks, and out on to the northern edge of the Atlantic water. The patrol sighted its first ice for the year on the 29th instant in the form of a small growler, latitude 44° 00′, longitude 49° 00′. The next day we made contact with the two southernmost bergs 44° 26′, 48° 40′. The patrol remained with the inshore berg (they being about 10 miles apart) for the last two days of March, during which time a drift of 1.4 knots per hour was recorded

to the southward, more or less parallel with the general trend of the Bank. It was noticed that the ice consisted of small bergs, which plainly showed the effects of last summer's disintegration in high latitudes; and, also, this is a characteristic form for the early season. An interesting incident was the case of a large berg which remained grounded about 7 miles southwest of Cape Race, in plain sight of the station, from the 6th day throughout the remainder of the month. It is estimated that there was a total of 26 bergs in the North Atlantic, south of Newfoundland, for the month. A normal March records 36 bergs south of the forty-eighth parallel and 4 south of the Tail, but this year none of the ice succeeded in drifting as far south as the Tail.

APRIL

The small berg which we had been standing by the last few days of March grounded on the 2nd instant in latitude 43° 31′, longitude 49° 28′, at a point where the contour of the Grand Bank projects abruptly out to the eastward. The drift covering March 29 to April 2 is shown on Figure 22. The neighboring berg, which on March 29 had been 10 miles farther offshore, drifted south faster in the current and was by this time no longer in sight, nor did we see it again in spite of a search covering the day of April 3. Its drift must have been offshore to the eastward as well as to the southward, where undoubtedly it was caught in the warm counter current. A small growler was reported on the afternoon of the 2d instant about 50 miles due south of the Tail. This was the southernmost position that ice had attained thus far this year, and we believe it to have been the same growler as one sighted by the patrol on March 30, 30 miles north of the Tail.

The patrol found a small berg and growler on the 4th about 35 miles almost due east of the Tail. We remained drifting near this ice the remainder of that day. It was moving southward at the rate of 1 to 1.5 knots per hour. A strong wind blew from the north during the night, and although we had been able to keep in sight of the growler, at daylight, the 5th, the berg was nowhere to be seen. Search was carried on for the entire day without success and we were forced to conclude that the berg had been set southeast, or east, into the warm offshore current. Since no ice was reported later to the southward, this behavior was somewhat substantiated.

Two small bergs were sighted April 7, the smaller in on the Bank and the larger about 10 miles east on the 100-fathom contour and about 25 miles north of the Tail. Fog shut in for the next two days, and when the patrol was next able to search, the larger of the two bergs was found southeast of the Tail, drifting in the heart of the current to the westward. We followed it as it swung to the northwest and later to the north, at about 0.9 knot per hour. Finally,

on the 13th, it entered water of practically no current in on the shoal of the Tail of the Bank itself. We remained near this berg until the morning of the 15th. It had calved several growlers, melted somewhat, and naturally was slowly becoming smaller. The water

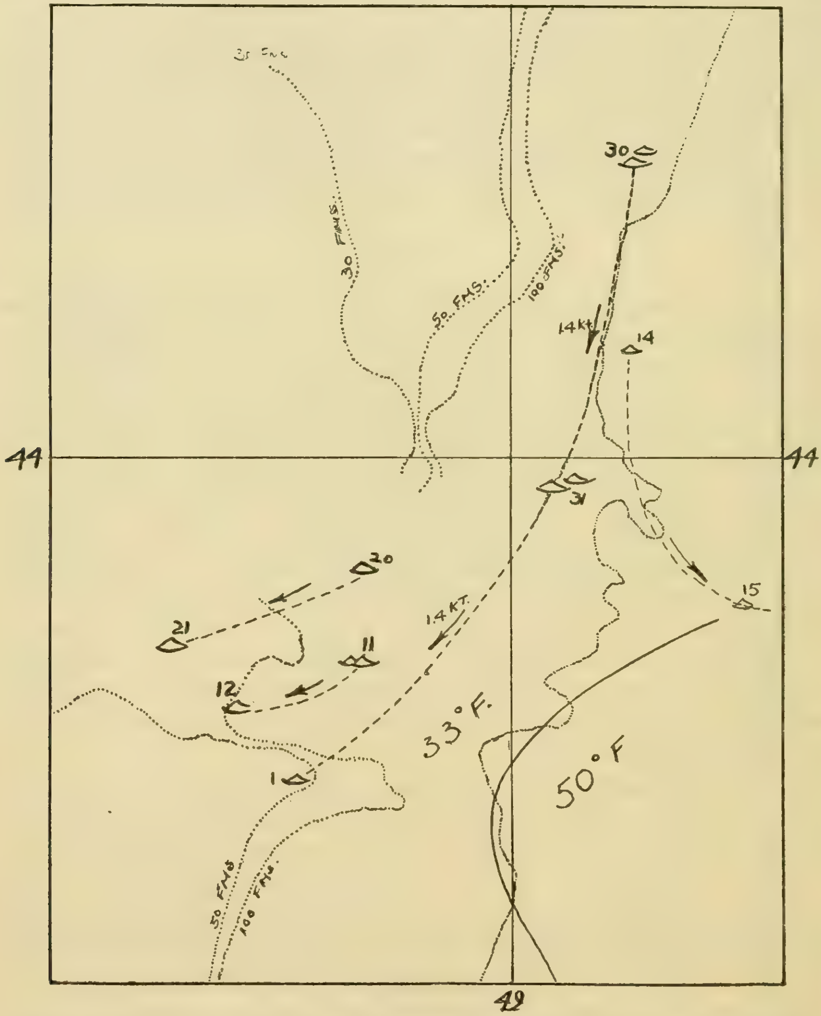

FIG. 22.—The drift of 3 bergs into the shallow water on the eastern side of the Grand Bank during April. Warm water from offshore pressing against the slope at this point is believed responsible for the deviation in the normal path of the ice

was relatively cool, 35° where it floated, and therefore not especially favorable for fast disintegration.

From the 10th to the 15th bergs were reported in positions scattered all along the slope from the Tail northward to the twenty-seventh parallel. A relatively great number of bergs, beginning with the 20th, were reported on the northern part of the Bank, as steamers began using tracks E bound for the Gulf of St. Lawrence.

The *Modoc*, on the 15th, searched around the Tail of the Bank to make sure no bergs had entered this area unobserved. April 16 the scouting was extended northward along the east side of the Bank and we sighted a large berg and growler near nightfall. The berg was surrounded by warm water, temperature 50° F., but inshore to the westward from its position we could plainly see the boundary line where the cold slope water began. The surface temperature for April 9 to 24 (fig. 54, p. 95) shows the relative positions of these two

FIG. 23.—April ice map. There was a total of 93 bergs south of the forty-eighth parallel during the month

temperatured waters. During the next 24 hours this berg drifted a total of 17 miles and then a strong northerly gale broke it up rapidly into many growlers.

The 18th, 19th, and 20th were days of excellent visibility and the patrol ship took good advantage of the opportunity to search the eastern slope of the Grand Bank from the Tail to the forty-fifth parallel of latitude. Only three bergs were found in this zone; all of them had been carried by the cold current inshore on to the shelf, 15 to 40 miles inside of the edge of the Bank.

The fourth berg to drift south of the Tail was reported by a steamer on the 25th about 100 miles west of the Tail on the southwest slope. The patrol stood by it for the next three days when it had completely melted away. It did not drift during this period over 15 miles from the position first sighted. This ice was thought to be one and the same last seen by the patrol on April 21 then in on the Bank about 50 miles to the northward.

The last day of the month the steamer *Newfoundland*, on her regular run between St. Johns and Liverpool, reported passing a total of 35 large bergs and numerous small ones on the extreme northern edge of the Grand Bank. This suddenly boosted the number of bergs south of the forty-eighth parallel for the month above normal. The position of this ice was somewhat to the westward of its usual path along the eastern slope of the Bank and therefore we expected that most of the bergs would eventually drift to southwestward, toward Cape Race.

Field ice was reported twenty times and on one day, April 7, it stretched in a broken line with few interruptions from near Cape Race to the east edge of the Bank in latitude 46° 00′. The farthest south position was recorded on the 13th instant when an open field was sighted in latitude 45° 14′ on the eastern side of the Bank. A field also projected out of the Gulf of St. Lawrence, its southern limits being reported 25 miles north of Sable Island on April 19.

One of the most striking points in connection with the ice distribution for the month of April is plainly to be discerned by glancing at the ice map for the period. (Fig. 23, p. 57.) Practically all the ice sighted and reported for the month was confined to the limits of the continental shelf. This was due to the prevalence of high atmospheric pressure over Canada and Newfoundland giving a consequent predominance of northeasterly winds combined with the oceanic fact that warm Atlantic water pressed closer to the continental slopes during April than is normal for the season. These two factors also interfered with the normal southward distribution of the Arctic ice.

There was a total of 189 ice reports relating to the positions of 93 bergs during the month of April south of Newfoundland (the forty-eighth parallel). Only 4 bergs, however, drifted south of the Tail of the Bank. A normal month provides for 83 bergs south of the forty-eighth parallel and 9 south of the Tail, therefore icebergs during April were slightly in excess of normal, but the southward distribution was not.

MAY

The 1st to the 5th days of May provided on the whole a very good visibility, affording the patrol an opportunity to search northward along the eastern slope of the Grand Bank. No ice was seen or reported, however, during this interval south of the forty-seventh

parallel. On the 6th and 7th days of May the *Tampa* sighted approximately 100 bergs, most of which were found in an area bounded by parallels 47° 50″ and 47° 30″ and meridians 50° 30″ and 51°, an area of about 36,000 square miles situated about 150 miles northeast of Cape Race. This great quantity of ice apparently was drifting southward eventually to ground on the northern part of the Bank; many of the bergs it was expected would succeed in drifting toward Cape Race while a much less number would probably follow the 50 and 100 fathom contours down the east side of the Bank. The fact that over 100 icebergs were in these regions on the northern slope of the Bank was considered an event of especial importance, particularly in view of the fact that the Cape Race tracks, leading directly through this area, would become effective May 15 and thus endanger those steamers bound to and from St. Lawrence ports. May 7 to 11 was spent near the southernmost known berg on the east side of the Bank near the forty-sixth parallel in 40 fathoms of water. The berg apparently was aground, or else there was no current at that place, because it did not change its position materially for four days. The patrol during this time broadcasted warnings every six hours regarding the unusual quantity of ice then present on the northern part of the Bank.

May 11 to 16, the fog settled over the cold, ice-infested waters on the northern part of the Bank, cutting off all opportunity to observe the behavior and drift of the bergs. It was with surprise that we received a report of a growler on May 15, in latitude 41° 57′, longitude 49° 53′, but the steamer which made the report added her inability to secure "sights" for the past two days and this naturally made the position very uncertain. In view of subsequent events, the presence of ice in this locality, approximately 60 miles south of the Tail, is deemed very unlikely. The patrol ship during the foggy spell, 11th to 16th, employed its time almost exclusively in making a survey of the circulation along the eastern slope of the Grand Bank and southward around the Tail (see p. 80).

May 21 was the first clear day for a fortnight and so we searched northward along the east side of the bank, and as guided by the boundary between the two currents, which now it had been possible to delineate on the current map just compiled. A considerable amount of ice was reported on the 21st instant. For example, the steamship *Calgaric* sighted about 38 bergs on the Cape Race tracks between longitude 49° 40′ and 50° 30′. These were thought to be part of the same large group last seen by the ice patrol on May 6.

May 23 to 27 were days of clear visibility and accordingly the patrol ship searched northward from the forty-fifth parallel all the way to the twenty-seventh parallel. A total of six bergs were sighted, which comprised the southernmost group on the eastern side of the Bank. The farthest south berg on the 23d instant was

recorded in latitude 46° 19′, longitude 47° 56′. The fact that there were so many bergs east of Newfoundland on the Grand Banks and that there were none south of the forty-fifth parallel was a truly remarkable condition. We made a report on this subject to the commander of the ice patrol on May 23, and, as it well describes the foregoing situation, it is included herewith:

I would like at this time particularly to invite your attention to the important events that have featured the ice patrol of 1927 and, as guided by the present conditions, to outline the probable general character and ice behavior for the remainder of the season.

As a result of research work abroad and at Harvard University carried out by the ice patrol, a prediction was made in March that approximately 396 bergs would drift south of Newfoundland in 1927. The termination of the field-ice season (usually the first half of May) now permits us to make a more accurate statement regarding the number of icebergs. The final forecast is close to 360 bergs, or a year quite similar to 1926, and one that is normal in number. To date there has been recorded a total of 224 icebergs south of Newfoundland, so that about two-thirds of the forecasted number have already put in an appearance. Both the ice and its time in season, therefore, are running along in harmony so far with predictions.

The first third of the season of 1927 was characterized by an unusual predominance of northeasterly winds, and this fact, combined with the presence of great masses of warm Atlantic water close in to the Grand Banks' slopes, interfered very markedly with the normal southward distribution of the icebergs. These facts were made the subject of a dispatch to headquarters on May 4 last. It is remarkable that nearly all the bergs this year have been confined to the northern part of the Banks and the coastal shelf, and only five bergs have drifted south of the Tail. None of these, moreover, have at any time endangered the United States-Europe steamship tracks.

The second third of the ice season, in which we are now well advanced, is distinguished for the cessation of the Labrador current southward around the Tail of the Bank, where normally it flows at 0.5 knot per hour at this time of year. A current survey covering about 40,000 square miles of area, equal to the size of the State of Pennsylvania, was carried out by the *Modoc* May 10–21, and the results of this work are shown on the current map of water around Grand Banks, May 11–21, 1927. The direction and velocity of the circulation have been calculated in accordance with methods contained in Coast Guard Bulletin No. 14 and includes the resultant movement of the mass in which an iceberg would normally float. It can be seen from the above current map that the warm offshore current presses unusually far inshore against the continental slopes. The current runs northward even, on the east side of the Bank in latitude 43° 50′, right in to the 100-fathom depth. Thus the warm current has tended to dam the icy current from the north (the Labrador) and has caused its main branch to be deflected south of Flemish Cap. The original of this chart is at present of invaluable assistance in guiding the patrol ship in its scouting work for icebergs.

Naturally a subject of special interest at this time is to learn, if possible, the behavior of the ice and the course of events during the last third of the season. Considering the present ice situation, viz, about 70 bergs and growlers on the northern part of the Grand Banks, plus 100 more bergs expected, and the position of the two ocean currents, leads to the belief that few, if any, bergs will succeed in drifting south of the Tail of the Grand Banks. In other words, present conditions indicate that the ice menace for the United States-Europe tracks will

continue to dwindle throughout the remainder of May and June. The Cape Race steamship tracks (used by St. Lawrence ships), however, where they cross the continental shelf, may expect to be hampered with about 100 more bergs and probably lasting well into August.

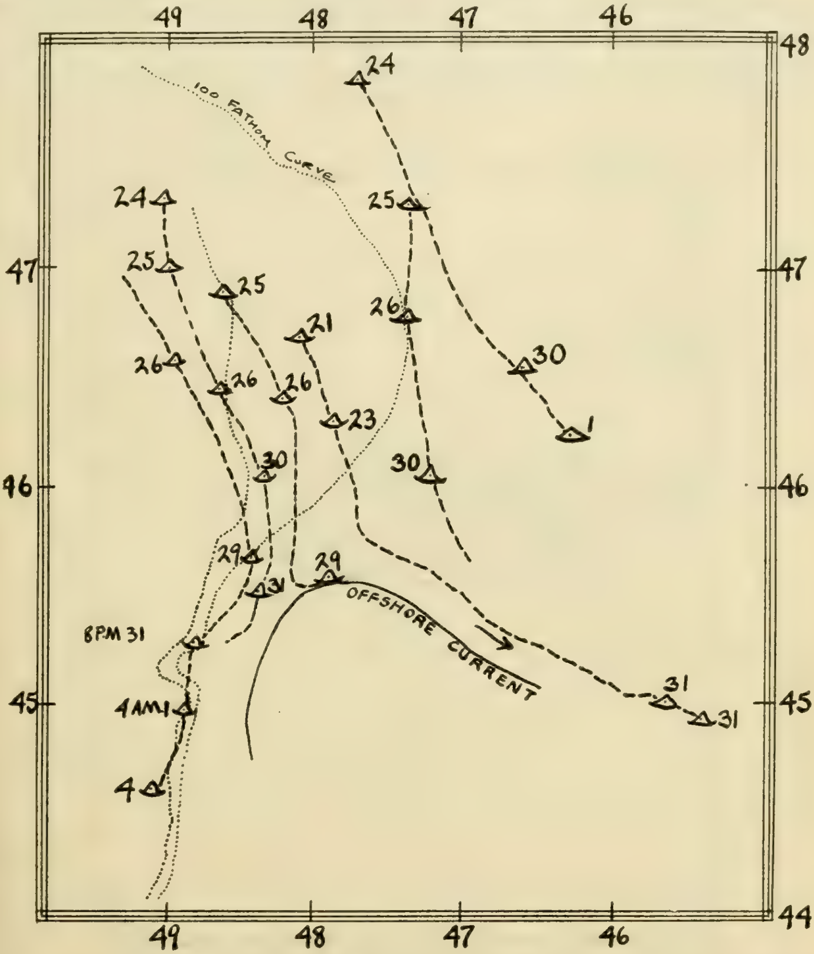

Fig. 24.—The northeastern Grand Bank promontory showing the drift of a number of bergs observed by the patrol May 24–31. The drifts were temporarily accelerated by a northerly gale which blew on the 25th and 26th instants

The summary is as follows:

First third of season:

(*a*) Normal number of bergs but held up in northern waters.

Second third of season:

(*b*) Inshore invasion of warm northeasterly countercurrent to the ice.

Last third of season:

Probable accentuation of (*a*) and (*b*).

A northwesterly gale blew on the 25th and 26th of May and its influence tended to accelerate the southward drift of bergs then on

the northeastern side of the Bank. Drifts averaging 1.2 knots per hour (30 miles per day) were observed and are shown herewith in Figure 24.

The southernmost iceberg, reported elsewhere on May 23, eluded our search on the 26th after the gale had subsided. The next day the wind changed to the south quadrant and low visibility and fog postponed further scouting operations. A berg was reported twice on the last day of the month in latitude 44° 53′, longitude 45° 38′,

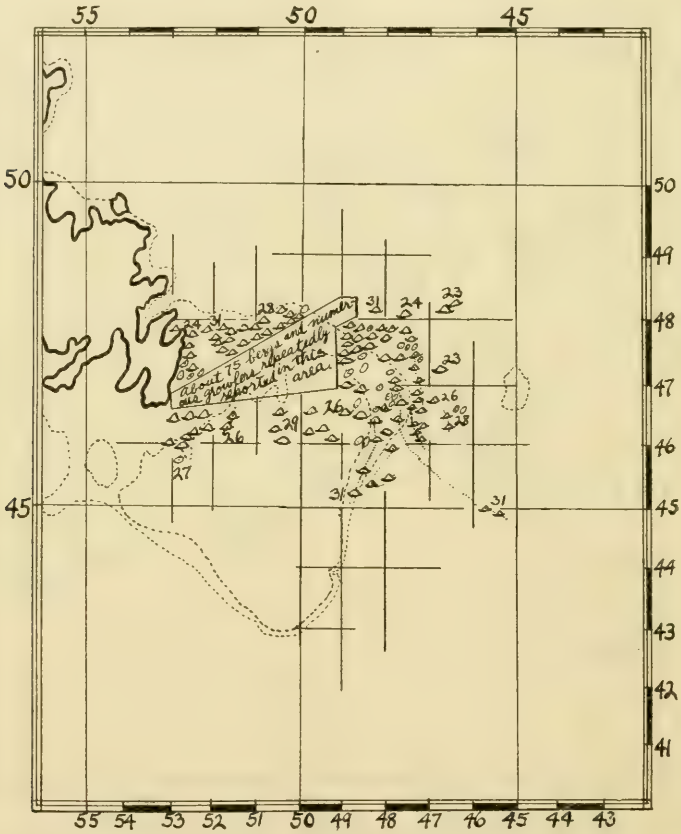

FIG. 25.—May ice map. There was a total of 153 bergs south of forty-eighth parallel during the month

and such a drift to the eastward from the position of the berg last seen on the 23d would indicate that this was one and the same berg.

The patrol ship sighted a total of five bergs on the 26th of May, strung out along the northeastern contour of the Bank and drifting southward more or less parallel to the general trend of the slope. Foggy weather again intervened on the 27th, 29th, and 30th, and, not being able to search for ice, we ran two lines of oceanographic stations normal to the slope just north of the forth-sixth parallel. On the 31st it cleared again and the patrol searched to the westward near

the slope in this same vicinity and two bergs were found fairly close inshore near the 100-fathom contour. It was believed that these two bergs were part of a group of six last seen on the 26th instant, and Figure 24 shows quite clearly their direction and rate of movement. The fact that they were observed to be drifting southward at 1.2 knots per hour agrees, moreover, almost exactly with the calculated rate determined by the density observations. We drifted near the inshore and southernmost berg the night of the 31st at the rate of 1 knot per hour to the southward, and thus ended the month.

Summarizing for May, we estimate a total of 153 bergs were south of Newfoundland (forty-eighth parallel), or 23 more than for a normal year. The most striking feature with reference to the distribution of the bergs was the complete absence of any ice during the entire month around the Tail of the Bank where the presence of 18 bergs is normal. The southernmost berg for the month, if we disregard the report on May 15, which was considered erroneous, was the berg observed on the 31st instant in latitude 45° 04′, longitude 49° 54′ or, no in other words, no berg was sighted within 200 miles of the United States-Europe steamship lanes during the month of May. This all tended, of course, to concentrate the ice on the northern part of the Banks where it gravely endangered steamships bound to and from St. Lawrence ports following the Cape Race tracks.

JUNE

The first two days in June were foggy, but in spite of this fact we sighted a small berg on the northeastern slope of the Bank. The next two days we spent on the current survey, but on the 4th instant we again sighted the berg last seen on the 1st. It had drifted south very little during the interval of three days and now was just south of the forty-fifth parallel. As the berg was apparently in the dead water on the Bank and consequently showed slight indications of drifting far from this spot, we left it again scouting northward for ice, and during the next three days searched the continental slope all the way to the forth-seventh parallel and westward to Cape Race. June 5, a Sunday, we sighted four bergs on the slope on the northeastern edge of the Bank and the next day located a total of 30 bergs distributed along the northern slope, the greatest number being found near latitude 47° 50′. This area has been inclosed on Figure 26 and labeled accordingly.

The *Modoc* assumed patrol duty on the 8th instant and immediately stood eastward, intending at first to search between the forty-seventh and forty-eighth parallels, just north of the area which the *Tampa* had recently covered. Fog and low visibility, however, modified these plans to a considerable extent, and so we were obliged to steer a straight course offshore to the edge of the slope. A few bergs,

nevertheless, were sighted along the 47° 30′ parallel, the work being further assisted by the steamship *Arabic* which passed during the afternoon of June 9 about 5 miles north of us. It was estimated that to date there were a total of 65 bergs present for the month south of Newfoundland (forty-eighth parallel), but nearly all of the ice was north of the forty-sixth parallel and distributed in various positions

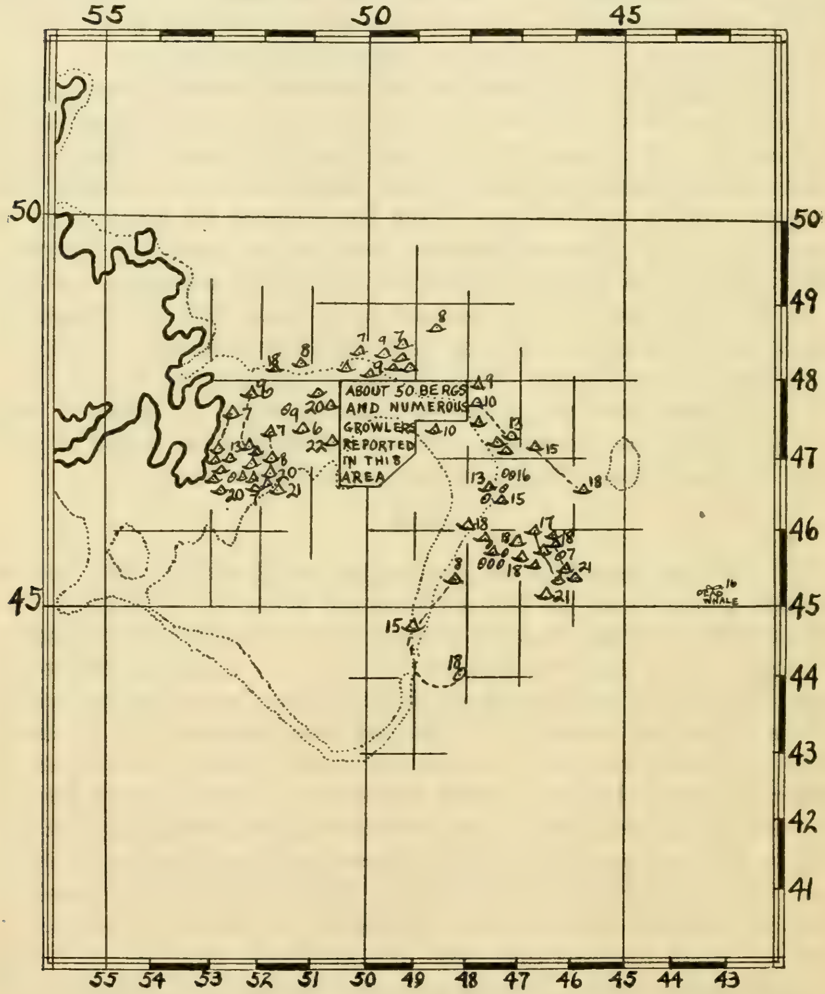

FIG. 26.—June ice map. There were approximately 95 bergs south of the forty-eighth parallel during the month

along the northern slopes of the Grand Banks. It appeared to exhibit no appreciable drift; if anything, it was working slowly to the southward farther in toward shallow water and, of course, breakup at a seasonal rate. Those bergs which were on the extreme northeastern side of the Bank, however, were being carried to the southward in a path more or less following the trend of the slope.

The direction and velocity of the circulation are clearly shown in considerable detail on the current map for the period, Figure 50, page 90.

The southernmost ice was the small berg previously mentioned in the first part of our remarks, just south of the forty-fifth parallel on the east side of the Bank. It was reported again and for the last time on the 8th instant, reduced now to the size of the growler in latitude 43° 54′, longitude 48° 22′. It evidently had drifted off the slope and been caught in the warm countercurrent which pressed into the westward at this particular point. (See the ice map for June, fig. 26.) Only four bergs succeeded in drifting south of the forty-sixth parallel prior to the 8th instant and all but one of these was deflected off to the eastward, south of Flemish Cap.

On June 10, when just north of the forty-seventh parallel and bound off the slope on a line of oceanographic stations, we sighted 12 icebergs scattered between the 50-fathom and 100-fathom curves. The southerly current in this zone was calculated to be 0.3 to 0.2 knot per hour. (See fig. 50.) Two of the same bergs were sighted again on the 11th, they having drifted southward to the forty-seventh parallel and followed the general trend of the slope, a drift which accords very closely with the current as calculated and drawn on the current map. (See fig. 50, p. 90.)

We were absent from the patrol grounds from the 13th to the 17th instant, but upon our return at the latter date a total of five bergs and several small pieces of ice were sighted in the vicinity of latitude 46° 00′, longitude 47° 00′, as shown on the ice map for the month. (Fig. 26.) This was believed to be the same ice as that last seen by the patrol on the 9th and 10th, then on the northern part of the bank. These bergs were reported again by a steamer on the 21st near the forty-fifth parallel and somewhat to the eastward, following a path in general conformity to the stream lines of the current. Few bergs were sighted on the northern tracks during this period, despite the fact that it was clear weather in that locality. We kept a careful record of the ships on the Cape Race tracks for a period of four days and estimated there were a total of 15 bergs the latter part of the month in this region. This would indicate that three-fourths of the number sighted up to June 9, or 50 bergs, had melted during the interim of two weeks, a sum which appears rather high. Probably some of the missing number might be found upon further search southward in the shoal water of the Bank, a locality which is seldom crossed by passing vessels.

We estimate there were a total of 95 bergs south of Newfoundland during the month, or 27 more than the average. The bergs remained concentrated on the northern part of the Banks, a condition which was also noted during May. Only one berg drifted south of the

forty-fifth parallel, and that one only to latitude 43° 54′, longitude 48° 20′, on the east side of the Bank, where it melted. When we left the ice regions, June 25, there were approximately 20 bergs on the northern slopes of the Grand Bank and 3 bergs near the forty-fifth parallel drifting to the eastward on the northern edge of the Gulf Stream.

SUMMARY

We now come to the summary of the season of 1927, the spring and early summer of which were characterized by a number of bergs

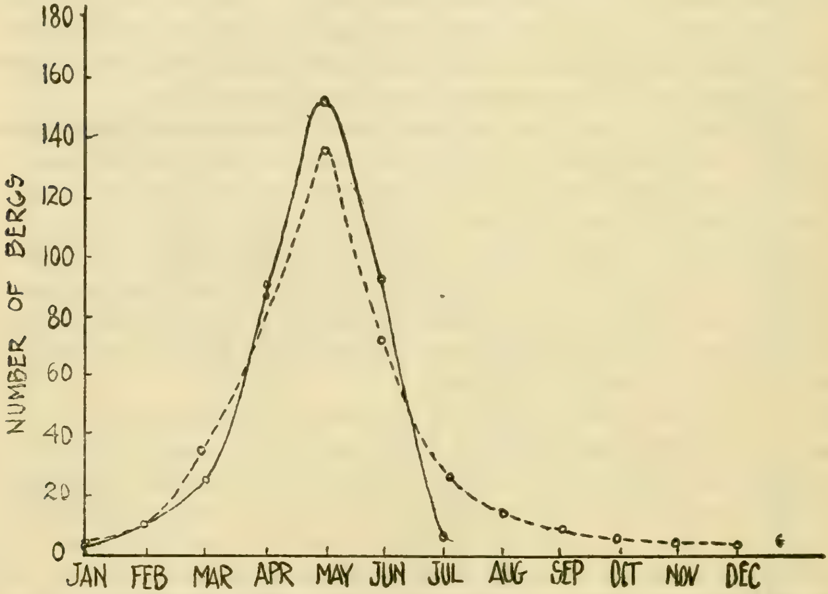

FIG. 27.—The distribution of icebergs south of Newfoundland, by months, during 1927. The full black line represents the actual observed numbers, while the dotted line represents the number which drifts south in a normal year

slightly in excess of normal. The distribution by months was as follows:

January	4	April	93	July	5	October	0
February	10	May	153	August	3	November	0
March	26	June	95	September	0	December	0

The foregoing table is shown graphically by Figure 27 appended herewith. The most striking fact in connection with the behavior of the icebergs in the North Atlantic during the spring of 1927 was their incomplete normal southward distribution. The bergs not being disposed as they usually are, consequently became concentrated from May 10 to June 15 in great numbers on the northern part of the Grand Bank where they constituted a distinct menace to steamships plying the Cape Race tracks. The uneven geographical distribution was attributed to the predominance of easterly and northeasterly winds during March and April combined with the inshore invasion of the warm Atlantic countercurrent.

The fact that only two bergs drifted as far south as the Tail of the Bank places the season of 1927 comparable with those in 1924 and 1925, two years noted for the absence of ice near the regular steamship tracks. The United States-Europe steamship lane routes during 1927, in fact, were at no time endangered on this score, and the conditions can best be presented by referring to Figure 28, which shows that during April there was only one berg that drifted as far south as the Tail of the Grand Bank, it being on April 13, its southernmost point, 90 miles to the north. During May the closest an iceberg approached the steamship lanes was on the 31st instant, when it was 210 miles away. June 8, the nearest that any berg drifted

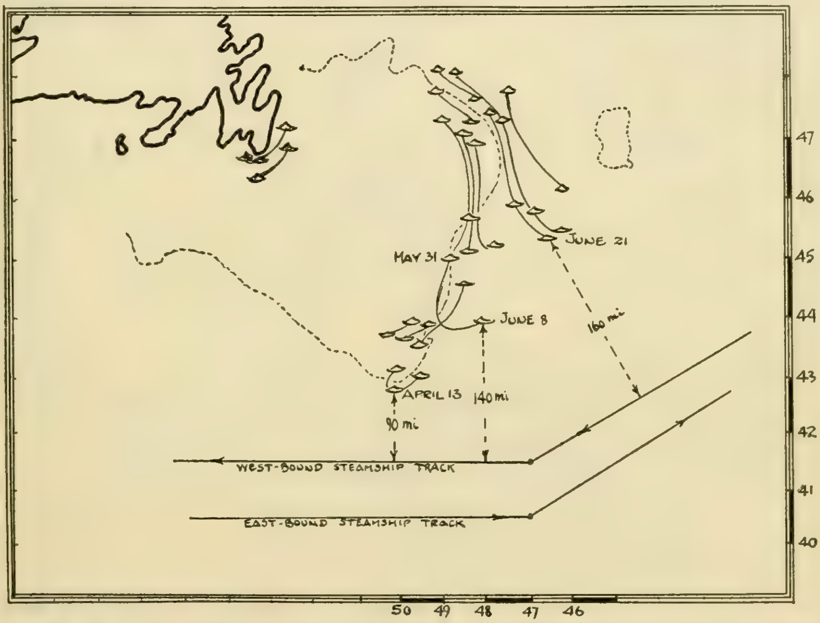

FIG. 28.—The nearest positions which bergs attained to the United States-Europe steamship tracks during 1927. Also, there is shown all the bergs that the ice patrol was able to follow in their drift

during the month, was 140 miles to the northwest of the United States-Europe lanes.

As in former years, the ice patrol kept track and recorded the drift of as many bergs as possible during the season, and the paths followed are shown on Figure 28. A record of all the icebergs that the patrol has been able to chart and follow since 1914 is shown as Figure 29.

As a result of the observations concerning the courses which bergs have followed near the southern end of their transport, we are including this year a map (fig. 30, p. 69) which shows diagrammatically the general berg paths and the most likely offshoots. Icebergs approaching the northern slope of the Grand Bank take any one of three paths a, b,

or c, depending upon the oceanographic and meteorologic conditions and the position of the ice geographically. Path c has six most probable points of departure. A berg embarking on path c may follow any one of the branched arrows e, f, g, h, and i. In early season—that is, in February and March—bergs characteristically

FIG. 29.—The drift tracks that bergs have followed since 1914 around the Grand Bank, as compiled from all records of the international ice patrol

follow branch d, but later in April, May, and June the ice follows any of the other branches farther to the south. Path i is, of course, the most dangerous for the steamships, as the ice there slowly crosses the United States-Europe steamship routes. Branch i, moreover, invariably lies between meridians 49 and 47, but fortunately it is a very small percentage of the total number of bergs taking path c that ultimately reach southward along branch i.

In order that the reader may have an idea of the comparative value of the year 1927 with respect to the number of icebergs that

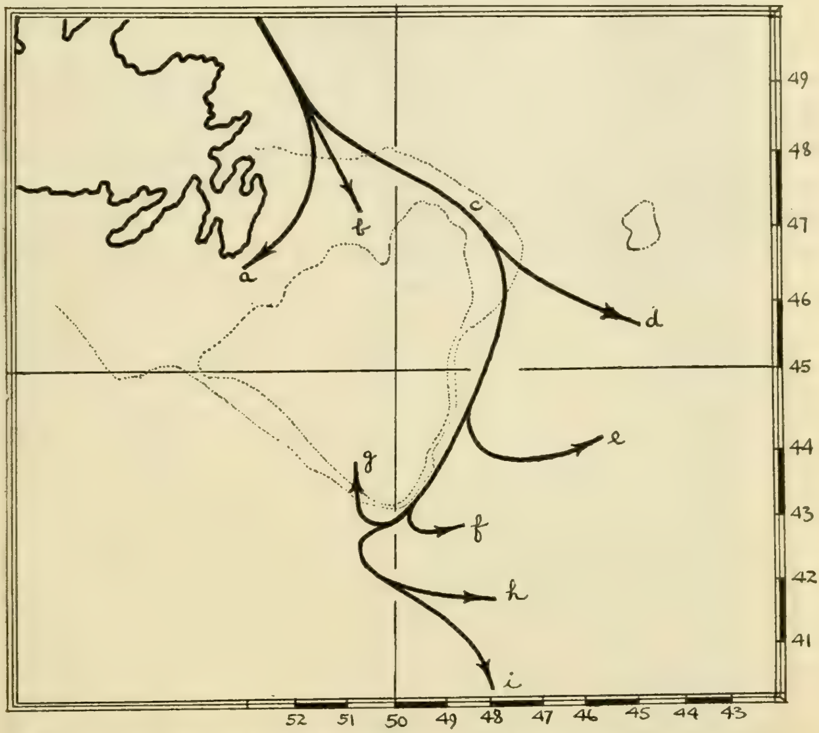

FIG. 30.—The main paths that icebergs are most liable to follow in the western North Atlantic when advancing southwards toward temperate latitudes. Branches d, e, f, g, h, and i are variations in the drift, once a berg has embarked along path c. This illustration is purely diagrammatic but it contains information where bergs are most liable to be met

drifted south of Newfoundland, there is appended below a graph of the iceberg character of the years 1880 to 1927, inclusive, arranged on a basis of 0–10. For a detailed count of the icebergs from 1900

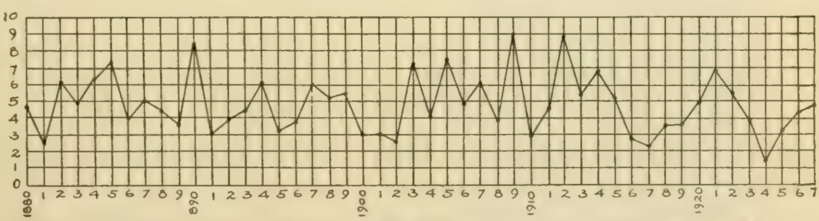

FIG. 31.—The iceberg character of the years 1880–1927 based on a scale of 0–10 mean value 4.8

to 1926, and also the departures in numbers from normal, please refer to Ice Patrol Bulletin No. 15, for 1926, pages 75 and 76. The iceberg character of 1927 is 4.8.

OCEANOGRAPHY

The fact that practically all the icebergs that drifted south of Newfoundland in 1927 remained to break up on the northern part of the Grand Banks, and that at no time during the season did ice threaten the United States-Europe steamship lane routes, gave the patrol more than ordinary opportunity to conduct frequent surveys of the ocean along the junction of the Gulf Stream and the Labrador

FIG. 32.—Oceanographic stations during 1927

current. We were thus able, during 1927, to follow more closely than ever before the processes that are continually altering the movement and behavior of the water masses in this interesting area around the ocean slopes of the Grand Banks. The state of the circulation resulting from the juxtaposition of the Gulf Stream and Labrador current, we have grounds to believe, is in successive months or weeks, never exactly the same, nevertheless there is an unmistakable tendency for the two antithetically charactered masses to

PLATE V.—THE FIRST BERG TO BE SIGHTED BY THE "MODOC" APRIL 11, 1927, LATITUDE 42° 43′ N., LONGITUDE 49° 45′ W.

PLATE VI.—BERG ALONGSIDE THE "MODOC" APRIL 16, 1927, SHOWING PRONOUNCED EROSION FROM ACTION OF SEA AND HIGH TEMPERATURE OF WATER

occupy positions which are more or less characteristic for the Grand Banks area. It is natural to speculate whether daily synoptic data for the ocean depths would show short-lived movements, similar to those that form in the atmosphere. The ice patrol, however, is almost exclusively concerned in the extent to which major changes in the circulation cause a deviation in the iceberg drifts. And this information, we find for all practical purposes, is contained in the current surveys, obtained monthly or bimonthly.

In carrying on the scientific investigations, the ice patrol follows a program laid down by the ice patrol board which deals with its general policies and plans. First, our principal concern during the particular ice season is tracing the developments in the circulation from March to July, as governing the drift of bergs approaching the southern end of their transit. For example, the observations taken by the patrol in the first part of April, 1927, indicated the scheme of circulation around the Tail of the Bank depicted on Figure 34 p. 75. And the correctness of this picture is evidenced by the fact that on April 10 to 15 a berg drifted southward, swung around the Tail, and stranded in on the Bank, in conformity with the stream lines that had been calculated. In order to be prepared for future bergs in April, a second investigation of the waters was made April 21 to 25, which showed that the general scheme of circulation had slightly altered. (Fig. 38, p. 78.) No more bergs, it happened, drifted so far south as the Tail, but if they had there were data on board which would have been ample to predict their probable paths. Information on the ever-changing positions of the currents, it is plain to see, is of great value to the patrol in conducting its ice service to shipping.

The other aspect of the oceanographic work is one with a longer view, which, after a few more years' mapping of the currents, sees much information resulting from a comparison of the maps from year to year. We believe that there are particular features which are more or less characteristic of all years; types that are easily subject to classification. Already, for instance, we are convinced, as a result of current data collected even over a short period of years, that an area of approximately 1,000 square miles, located on the southwest slope of the Grand Bank, is normally the seat of an anticlockwise rotating eddy. This phenomenon (and it is important from our viewpoint) explains why bergs passing close by the Tail so often drift inshore and remain to melt in the shoal water on the Bank. Therefore, the greater the number of systematic surveys of the circulation, the better we are able to understand what formerly seemed a chance disposition of the ice.

There were five dynamic surveys made of the waters of the ice regions in 1927. The positions at which observations are usually made (C. G. Bull. No. 15, p. 87) were not adhered to closely in 1927, be-

cause experience now permits certain modifications in the program. Twice during 1927, for example, we were able to gain a good idea of the currents from a map based upon only 20 stations scattered net-like over the region around the Tail of the Bank. The other three surveys, however, dealt with a larger area situated along the eastern slope of the Bank, and consequently they embrace more stations than the earlier investigations. (See fig. 32, p. 70.) But the general plan of sections placed at right angles to the currents underlies all of the observational work. The choice of the particular area to be surveyed, it should be remarked, is often dependent upon the relative position of the ice and the patrol vessel, because we wish never to be far distant from the southernmost bergs.

A short description of the methods employed to determine the currents is given herewith. First we decide on the ocean area in which it is most desired to learn the direction and the velocity of the circulation. Usually the waters between the United States-Europe steamship tracks and the Tail of the Grand Bank are of first consideration, because it is there the course of the cold current and its freight of ice are subjected to the greatest variations in direction. When respite from ice scouting occurs, the patrol ship cruises over this zone; stopping and taking stations every 15 to 20 miles, the points of observation being distributed equidistant over an area which often approximates in size the State of Pennsylvania.

A thoroughly drilled oceanographic team of four to six men starts work when the vessel becomes stopped at the observation point. As soon as the ship is "dead" in the water, a heavy weight attached to a small wire rope is lowered over the side and an instrument called a water bottle is securely clamped to the wire at the rail. The meter wheel, which records the length of wire run out, is next set at zero, the winch brake released, and the line allowed to unreel rapidly off the drum. Six or seven water bottles are successively attached to the wire at those levels at which we desire observations, until we reach a depth of 750 meters, the limit to which the ice patrol has carried the work. A water bottle, it should be explained, is an ingenious mechanical instrument which, at the will of the observer, captures a sample of the sea water in which it is immersed and simultaneously registers the temperature by means of attached thermometers. When all the water bottles are suspended on the wire at the proper depths, a weight, called a messenger, is placed on the wire and, sliding down, trips the first bottle. This causes the instrument to automatically make a record and also release a second messenger which in turn slides down to the second bottle, and so the operation is carried on to the last bottle of the series. The wire is then reeled in, the thermometers read, and the samples of the water from the respective depths are bottled, the total elapsed time at a station being from 20 to 30 minutes.

The bottled water is next siphoned into the test cells of the electric salinometer, an instrument which conveniently measures the total solid salts of the sample per thousand grams of water. (See C. G. Bull. No. 12, pp. 136–147; and Bull. No. 15. p. 125.) There were over 1,000 samples of sea water tested for salinity by this instrument during the patrol of 1927. The next step is to convert temperature and salinity values into terms of specific gravity, and from these latter the currents are calculated. The final result of the current surveys are such sketches and maps as Figures 33 to 52. Such current maps, moreover, have proved of great value to those in direct charge of the patrol, as they reveal information on the probable movements of the ice.

The installation in 1927 of new electric oceanographic winches to lower and hoist the instruments materially shortened the time spent at stations, and thus allowed a greater number to be taken. A total of 208 stations, nearly double the number of any previous season, were located around the Atlantic faces of the Grand Bank.

The surveys were made in the following order: The first part of April the so-called critical area around the Tail of the Bank was surveyed. Two weeks later observations were repeated in the same region to determine what changes, if any, had taken place. The first part of May the *Modoc* investigated the water mass lying along the east side of the Bank from the forty-sixth parallel southward around the Tail and for a distance of 150 miles to the westward along the southwest slope. Three weeks later the currents were traced along the east side of the Bank by the *Tampa* for a distance of 120 miles north and south of a point on the slope where the warm offshore water pressed in. The final investigation for 1927 was conducted by the *Modoc* the second two weeks in June, and embraced the entire eastern slope of the Grand Bank from its northern reaches to the Tail and eastward to Flemish Cap. This was the most extensive survey ever conducted by an ice patrol vessel, and presented to those in charge of the work a most detailed picture of the ice and current conditions near the close of June. It was upon the information contained on the current map for this period that the strong recommendation to discontinue the patrol June 25 was based.

DISCUSSION OF THE CIRCULATION IN 1927

The total of 208 stations has, for the purposes of illustration and discussion, been divided into five groups or sets, arranged chronologically for the periods observed. Each set contains four maps—one dynamic topographic of the sea surface, one showing the direction and velocity of the currents as calculated, one representing the distribution of the cold and warm water, and one showing the relative positions of the fresher and salter masses.

Set I. April 6 to 10, 20 stations. (Figs. 33, 34, 35, and 36.)
Set II. April 21 to 25, 21 stations. (Figs. 37, 38, 39, and 40.)
Set III. May 10 to 18, 59 stations. (Figs. 41, 42, 43, and 44.)
Set IV. May 29 to June 3, 31 stations. (Figs. 45, 46, 47, and 48.)
Set V. June 9 to 25, 68 stations. (Figs. 49, 50, 51, and 52.)

The dynamic maps, Figures, 33, 37, 41, 45, and 49, show the topography of the sea surface compared to the 750 decibar (meters) surface, the assumption being that this plane was level. The numbers, viz, 728.80, 75, 728.70, etc., represent the height of the surface of the sea in dynamic meters above the 750 decibar base plane.

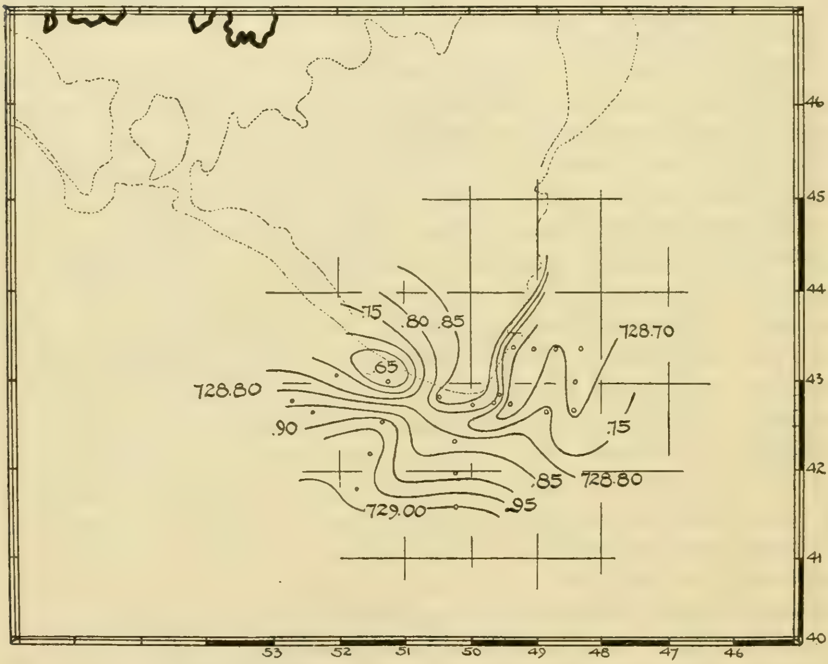

FIG. 33.—Set I. Dynamic topographic map drawn from observations made at stations 631–651, April 6–10, 1927. This map is read the same as an ordinary isotaric weather map

Such maps are quite similar to the ordinary isobaric weather maps, and, for all practical purposes, the dynamic contours represent the stream lines of the currents, as explained in Coast Guard Bulletin No. 14.

SET I

The oceanic situation April 6 to 10 may be described as consisting of an ellipitical depression in the sea surface centered over the southwest slope of the Grand Bank. From this center a trough extended to the eastward around the Tail, more or less paralleling the contour of the slope, and separating water of higher elevation, which lay in on the Bank, from that offshore to the southward. Figure 33 shows that the sea surface was highest at a point about 100 miles southwest

of the Tail, thus recording a slope of about 30 centimeters in a distance of 35 miles. Calculation of velocities shows that a rapid current of 1.4 knots per hour flowed toward the east at the outer stations along the southwest slope, and an equally strong set to the southward took place along the east side of the Bank about 45 miles north of the Tail. The current arrows on Figure 34 clearly show the manner in which the current hugged the 100-fathom contour to the Tail, where it split, one branch flowing for a short distance to the westward and then bending to the northwest to overflow the shallow part of the shelf. The outer branch turned abruptly

Fig. 34.—Set I. The direction and velocity of the currents, April 6–10, 1927. The drift of an iceberg April 12–15 is also shown

back to the eastward at the fiftieth meridian and joined the more voluminous masses of the Gulf Stream. Particular interest is attached to two features of the circulation which were in process when this picture was recorded: (1) a tendency on the part of the Gulf Stream, as shown in the shape of the current arrows, to force itself in toward the slope of the Bank; (2) the anticlockwise eddy seated over the southwest slope of the Bank, which appears to have received its life from the inner current on the north and also from the outer current on the south. In such a case it had a mechanical source rather than a hydrostatic cause. Its presence, however, was accountable for the only berg that reached the Tail in 1927, to be carried to the northwest, inshore, where it eventually melted. (See fig. 34.)

FIG. 35.—Set I. The distribution of cold and warm water at the 50-meter level, April 6–10, 1927

FIG. 36.—Set I. The distribution of salinity at the 50-meter level, April 6–10, 1927

The distribution of cold and warm water April 6 to 10, at a depth of 50 meters, is shown on Figure 35. We now see that the southerly drift along the east side of the Bank of 1.4 knots per hour must have been Labrador current because of its extremely low temperature. The much warmer water, greater than 10° C., which lay about 35 miles seaward of the continental edge was "Gulf Stream." The distribution of the salinity at the 50-meter level, as contained on Figure 36, supports the conclusions drawn from the foregoing figures of the set.

SET II

After an elapse of two weeks we repeated the survey of the area just discussed in order to determine what changes, if any, had taken

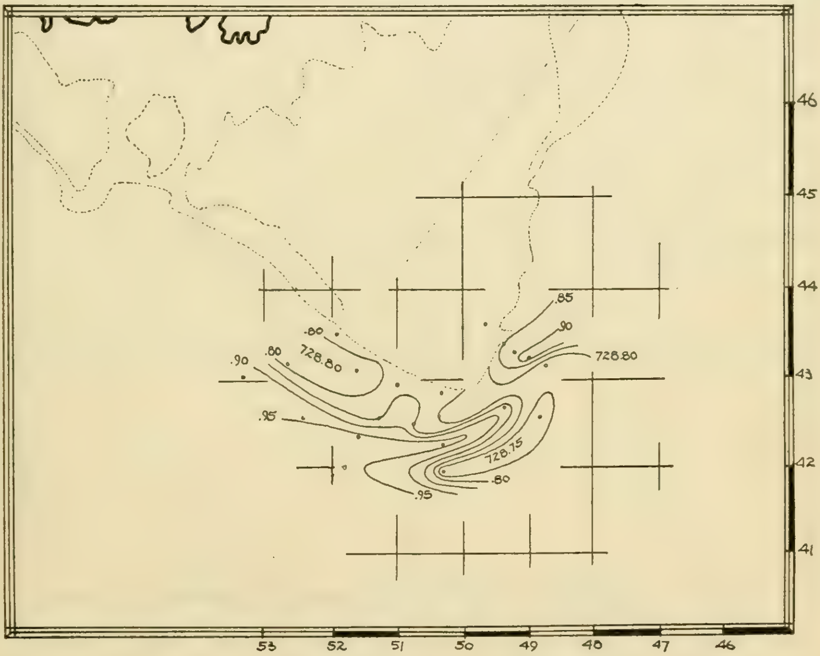

FIG. 37.—Set II. Dynamic topographic map drawn from observations made at stations 652–673, April 21–25, 1927. This map is read the same as an ordinary isotaric weather map

place in the scheme of circulation around the Tail of the Bank. We found the shallow depression in the sea surface still persisting in about the same position it had had two weeks previously over the southwest slope. A second depression, centered about 50 miles southeast of the Tail, was almost completely cut off from the Grand Bank by a ridge of relatively high contour, which had developed since the preceding survey, and was thrust from west to east, past the Tail between the forty-third and forty-second parallels. The surface of the sea on the eastern side of the Bank, between the forty-third and forty-fourth parallels, was elevated, the dynamic contour of 728.85

dynamic meters projecting in to the 100-fathom curve. The current velocities on Figure 38, when compared with those of two weeks previous (fig. 34) show a considerable slackening, except south of the Tail, where the outer current bent back toward the southwest at the very rapid rate of 1.7 knots per hour. There is also evidence that the outer current as a whole had pressed in more closely toward the slopes of the Grand Bank, especially on the east side of the latter, between the forty-fourth and forty-third parallels, where the cold water was probably dammed from following its usual path along the continental edge. The dynamic calculations in this instance are further supported by the drift of a large iceberg (fig. 38) first sighted by a steamer

FIG. 38.—Set II. The direction and velocity of the currents, April 21–25, 1927. Numbers 66–70 represent a line of oceanographic stations taken by the "Michael Saro," 1910. See p. 80

on April 14 and then by the patrol on the 16th, and again for the last time on the 17th. Obviously its track agrees closely with the direction of the currents as calculated. It is also interesting that on April 16, a calm smooth day, we could plainly see tide rips about 2 miles westward of this berg. This must have been near the boundary of two currents (fig. 38), because later in crossing this zone we experienced an abrupt drop in the temperature.

Figure 39, when compared with Figure 35, shows that the temperature of the water around the Grand Bank grew much warmer during the month of April, except offshore from the southwest slope, where it had cooled somewhat. The distribution of salinity (fig. 40) in general corroborates the temperature chart for the same period.

FIG. 39.—Set II. The distribution of cold and warm water at the 50-meter level, April 21–25, 1927

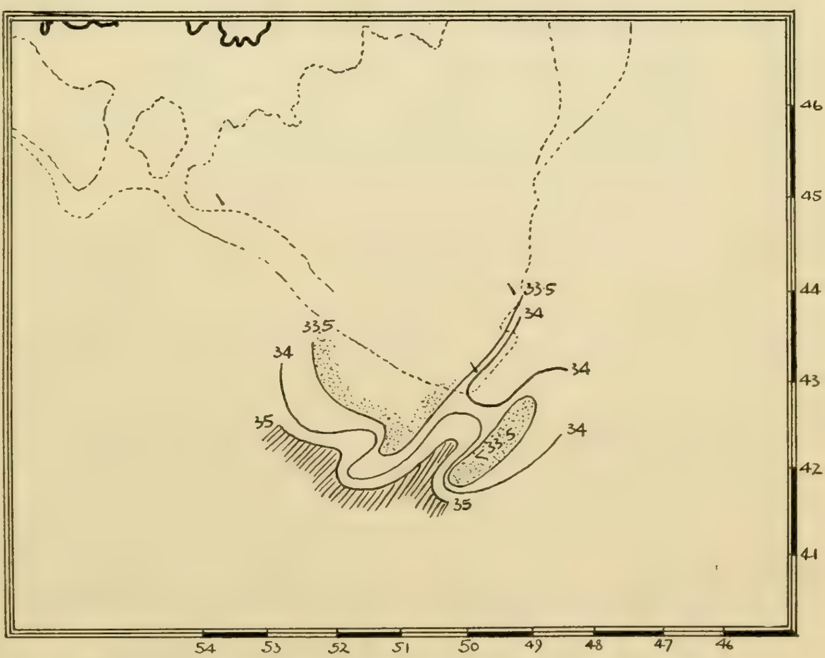

FIG. 40.—Set II. The distribution of salinity at the 50-meter level, April 21–25, 1927

The indentation south of the Tail of warm Atlantic water into the mixed zone and its counterflow toward the southwest, as shown on Figure 38, p. 78, brings to mind a similar condition found by the *Michael Sars* on a section across this region in 1910. (Murray and Hjort, The Depths of the Ocean, p. 99.) As a result of the observations of this expedition, the impression is often held that the Gulf Stream south of Newfoundland is split by a cold southwesterly current, but as such a phenomenon has seldom been observed the true condition has remained obscure. The ice patrol observed a similar location of the two currents south of the Grand Bank in 1923, but evidence in the form of surface temperature charts proved the cold current to be temporary and caused by the great irregularity and distortion of the boundary between coastal and oceanic masses. A multitude of curling tongues and votices is a natural accompaniment along the border of two opposing ocean flows, and our present-day ability to plot the stream lines of the currents reveals hitherto unsuspected phenomena concerning the behavior of the water particles. The fact that the course of the northern edge of the Gulf Stream south of the Grand Bank is found so extremely sinuous, turning and bending back so sharply upon itself, strikingly emphasizes the great mobility of water in the open sea.

SET III

This set of observations, taken May 10 to 18, extends the view from the neighborhood of the Tail, where the two former surveys stopped, to the circulation along the entire eastern side of the Bank. This is the first time that a dynamic survey has ever been made of this particular region. The axis of the depression previously observed off to the southwest of the Grand Bank was moved so much closer in to the continental edge, as shown by Figure 41, that the rising slope to be expected inshore of it no longer falls within the picture. Consequently no westerly current appears there, though such a set no doubt existed some few miles in on this part of the Bank. At the same time the extreme tip of the projection of high surface previously extending from west to east in the offing of the Tail had flattened out and the low pool to the southeastward had also shifted correspondingly to the westward. A second trough in the sea surface, as embraced by the dynamic contour of 728.70 dynamic meters, is seen on Figure 41 projecting offshore from the shelf for about 80 miles between the forty-third and forty-fourth parallels, and this formation is probably a development of the shoaler depression seen in the same general location on Figure 37. The ridgelike elevation to the north of it persists in extending southwestward, even abutting the 50-fathom curve of the Bank.

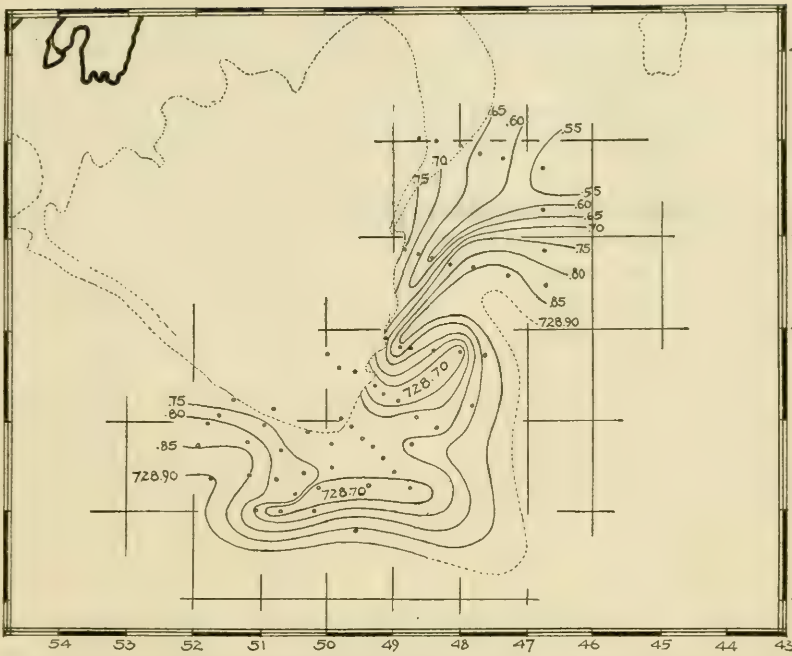

FIG. 41.—Set III. Dynamic topographic map drawn from observations made at stations 678–737, May 10–18, 1927. This map is read the same as an ordinary isotaric weather map

FIG. 42.—Set III. The direction and velocity of the currents, May 10–18, 1927

The currents resulting from the dynamic topography just described are shown on Figure 42. The outstanding feature of the circulation is the sinuous form of the outer current, swirling inshore quite markedly at two points along the slope—first on the southwest side of the Bank and later again on the eastern side near the forty-fourth parallel. The ice patrol has never before been able to secure such a satisfactory picture of the currents north of the Tail, as shown on Figure 42. Scanty records have led us to suspect, however, that the outer current often tends to pinch off the Labrador current and the supply of bergs, between the forty-fourth and forty-fifth parallels, more than at any other point along the slope north of the Tail. This locality is often the key to the ice situation.

After contemplating Figure 42, it is natural to inquire what causes the current to sweep inshore so much closer near the forty-fourth parallel than at other places around the Grand Bank? Let us approach the question by regarding the circulation over a wider area. The cause of flow of the Gulf Stream, for instance, has been the subject of great discussion among scientists, and one popular theory ascribes the motive power to propulsion imparted in the Caribbean. It can be proven, however, that if the water masses forced northward out of the Florida Straits depended solely upon their inertia of motion, the flow would entirely dissipate a quarter of the way to Hatteras.

The movement of the water particles along the eastern continental edge of North America is, we believe, on the other hand, chiefly a hydrostatic phenomenon caused by the mixing of coastal and oceanic water, forming thereby a heavy water zone. The sequence of events is as follows: First there must be two water masses of different salinity and temperature brought into contact. Under natural conditions the saltier mass freshens and the fresher mass salts. The warmer mass cools and the cooler mass warms, all with the important result that such a process creates heavier water than that which originally prevailed. This fact can be proven by taking equal samples, standard for each type of water, coastal and oceanic, around the Grand Banks as follows:

	Salinity	Temperature	Specific gravity
		°C.	
Labrador current	33.10	−1	26.53
Gulf Stream	35.20	13	26.56
Mixture	34.10	6	26.86

The density of the resulting mixture, 26.86, it is seen, is greater than that representative for either Gulf Stream or Labrador current.

Taking up the sequence again, we find that the water particles in the mixed zone, because of their greater specific gravity, continually tend to sink, but, due to the effect of earth rotation, actual movement is relegated to a lateral path more or less at right angles to the gradient. This, in brief, is the theory of marine currents in the region with which we deal.

The particular path an ocean current will follow, therefore, can be foretold provided the geographical position of dissimilar charactered water be known. The general distribution of coastal and oceanic areas, moreover, is governed to a great degree by the topography

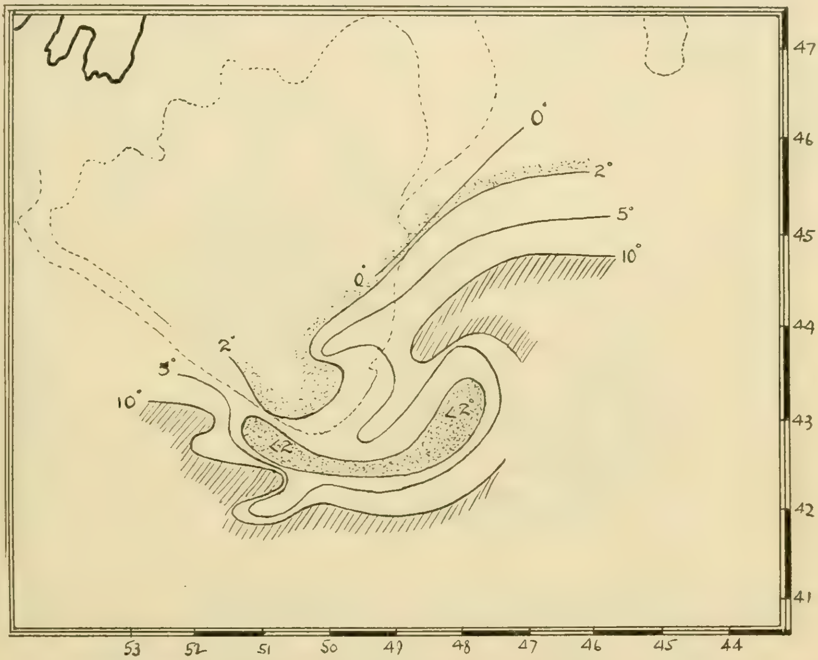

FIG. 43.—Set III. The distribution of cold and warm water at the 50-meter level, May 10–18, 1927

of the sea basin, and even where the depths are comparatively great we find their reflection in the physical character of the overlying masses. In this connection it will be observed that the Grand Banks after stretching out in a southeasterly direction from the Tail suffers considerable embayment near the forty-fourth parallel. Warm salty water is usually found filling this submarine valley, and near its head, which is close to the 100-fathom curve, we should expect to find the transition zone of the water and consequently the boundary between the currents.

The position of the cold and the warm water around the Grand Bank May 10 to 18 is shown on Figure 43. The two most interest-

ing features are the location and the shape of the elongated body of water less than 2° C. and the irregular inner edge of the warm offshore water as outlined by the 10° C. isotherm. The distribution of salinity at the 50-meter level (see fig. 44), when compared with Figure 43, indicates plainly that the water in closest to the Bank was Labrador current and the water farthest out in the basin was warm salty Atlantic.

The last week in May we searched along the eastern side of the Bank in the cold current and ascertained that there was no ice south of the forty-sixth parallel. Several bergs, however, were on the

FIG. 44.—Set III. The distribution of the salinity at the 50-meter level, May 10–18, 1927

SET IV

northeastern slope, the largest group that had been in that locality during the season. It appeared probable, therefore, that they might drift farther south along the edge of the Bank, in which case a recent survey of the currents would be highly desirable.

Figure 45 is a dynamic topographic map obtained from investigations carried on May 29 to June 3, and is based upon a total of 31 stations. The striking feature of the picture is an elliptically shaped depression, as outlined by the dynamic isobath of 728.60 dynamic meters, which lay centered on the eastern side of the Grand Bank near the forty-fifth parallel. High aquain rose on all sides except to the north, in which direction a trough extended to the limit of the observations.

The circulation resulting from such a dynamic topography is shown on Figure 46. A current ran southward along the edge of the slope to the forty-fourth parallel, where most of it was turned back to the north, joining a countercurrent which swept in from offshore at this point. The inner edge of the countercurrent between the forty-fourth and forty-fifth parallels was only 30 miles seaward of the

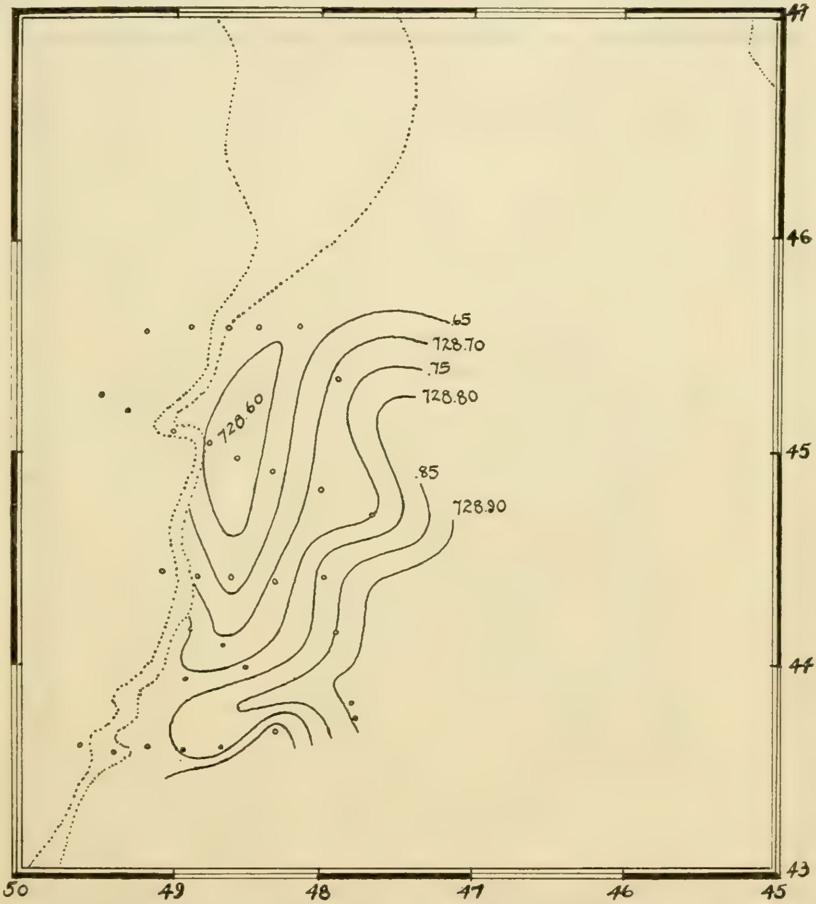

Fig. 45.—Set IV. Dynamic topographic map drawn from observations made at stations 739–769, May 29–June 3, 1927. This map is read the same as an ordinary isobaric weather map

100-fathom curve, but it later became deflected offshore just north of the forty-fifth parallel, and without doubt eventually passed south of Flemish Cap.

The form of the isotherms and the isohalines are unusually instructive when compared with the current arrows on Figure 46. The position of cold and warm water, also of the salt and the fresh masses, indicate the southward flow next to the slope to be that

known as Labrador current, while the current from offshore sweeping in toward the slope can be none other than Gulf Stream.

The most interesting event, at least from the standpoint of the patrol, was the presence of an iceberg which drifted in this area immediately after the completion of the current survey. It was first sighted on May 30 on the northeastern part of the Bank, and was seen again on the 31st, June 1, and the for the last time on the 4th,

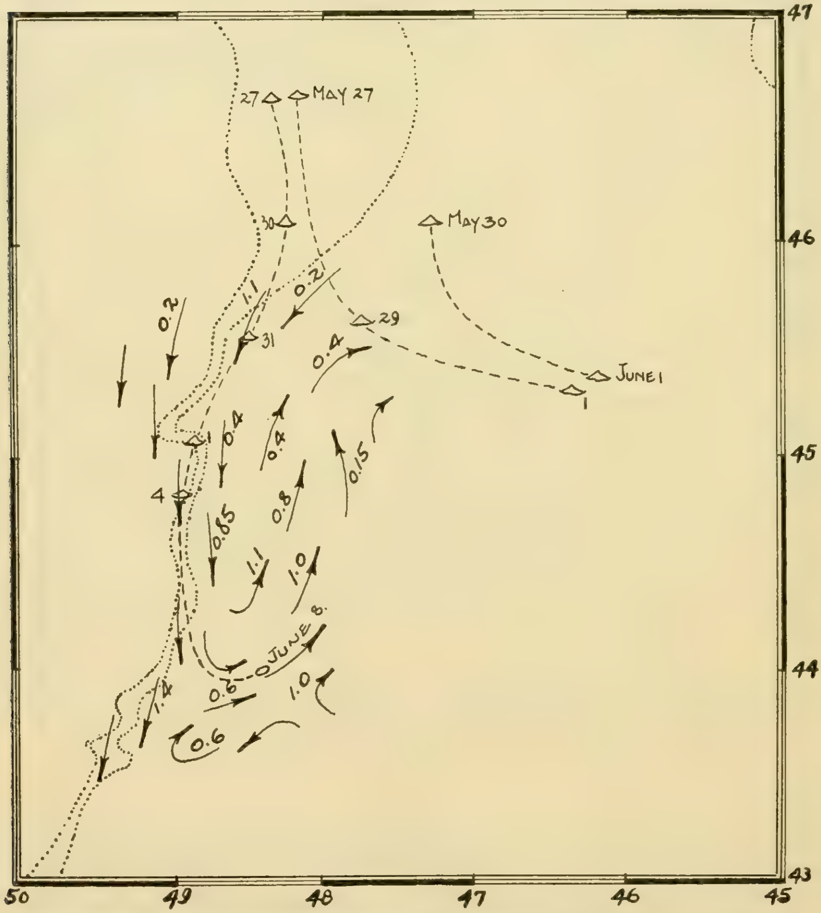

FIG. 46.—Set IV. The direction and velocity of the currents May 29–June 3, 1927. The track of an iceberg is shown from May 27–June 8, 1927, closely agreeing with the calculated circulation

when it was only the size of a growler. Its path, shown on Figure 46, closely conformed to the general scheme of circulation as calculated from physical observations of salinity and temperature. Its rate of drift also agreed quite well with the velocities as computed by Bjerknes's formulae. This is one of the best comparisons that the ice patrol has been able to obtain between dynamic equations and the actual drift of a floating object.

SET V

The last survey of the currents for the season of 1927 was begun June 9 on the northeastern slope of the Grand Bank near the forty-eighth parallel, and developed southward to the Tail, where it was completed June 25. A total of 69 stations were scattered fairly equidistantly along the east slope of the Bank and out into the basin as far as Flemish Cap. One station was taken well to the eastward of the others, offshore near the fortieth meridian, but it was used only

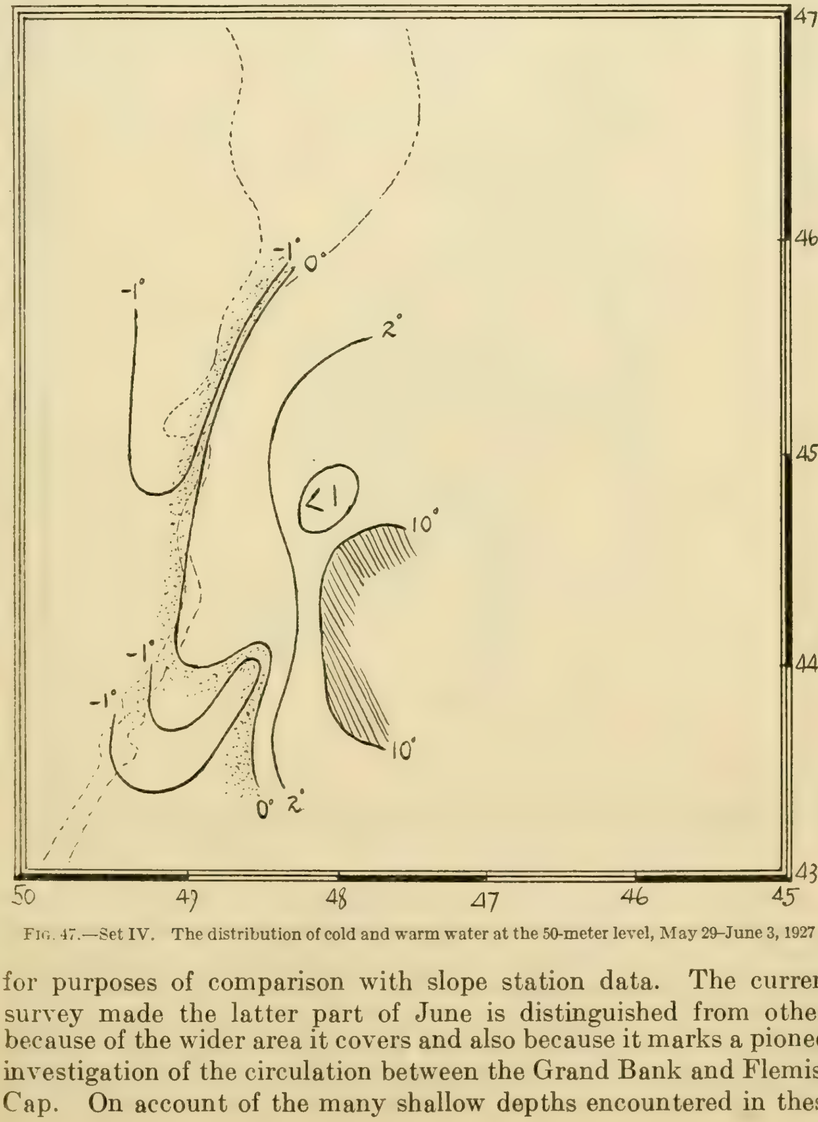

FIG. 47.—Set IV. The distribution of cold and warm water at the 50-meter level, May 29–June 3, 1927

for purposes of comparison with slope station data. The current survey made the latter part of June is distinguished from others because of the wider area it covers and also because it marks a pioneer investigation of the circulation between the Grand Bank and Flemish Cap. On account of the many shallow depths encountered in these

regions, it was impossible to employ a sufficiently deep common decibar plane, so in order to express the dynamic topography of the sea surface it was necessary to follow methods which give dynamic differences between adjacent pairs of stations. The figures, therefore, appearing on Figure 49 are expressed in terms of dynamic millimeters which are reckoned above a zero point located a short distance northeast of Flemish Cap.

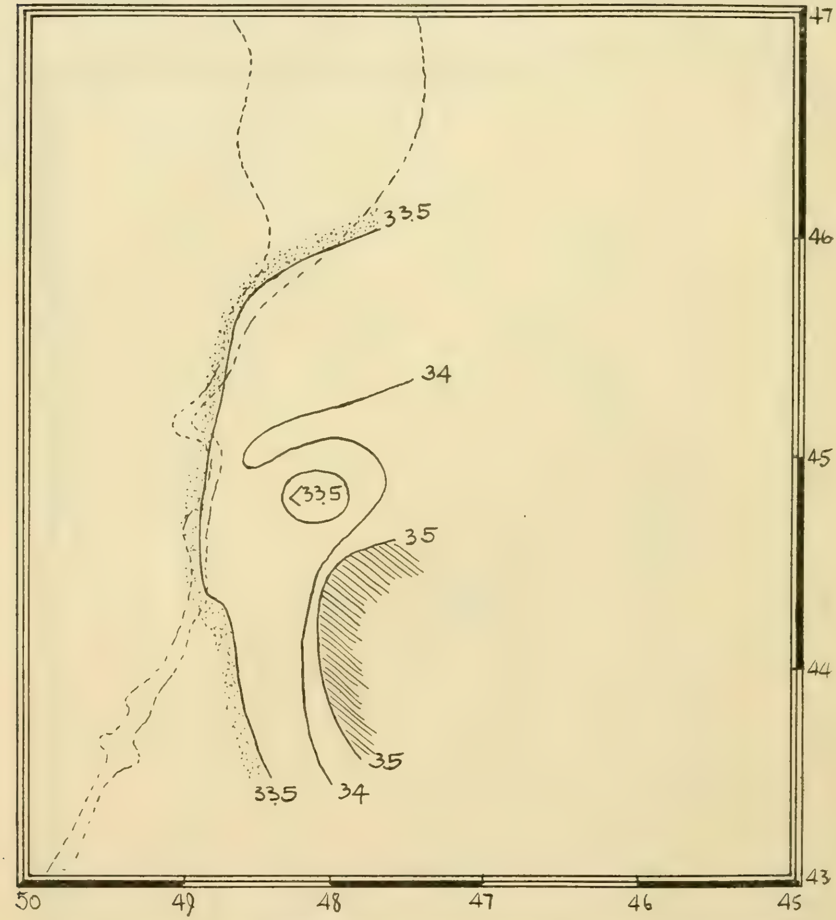

FIG. 48.—Set IV. The distribution of salinity at the 50-meter level, May 29–June 3, 1927

Figure 49 is featured by two general areas of high sea surface, one over the Bank and the other out in the deep water to the eastward. We took no observations over Flemish Cap itself, but in all probability they also would have shown the surface of the sea relatively high. On the other hand, a deep and narrow furrow lay stretched along the edge of the Bank between the forty-fourth and forty-fifth parallels, with the lowest point of the sea surface located north of

Flemish Cap at the outer end of our first line of stations. The surface was also moderately depressed over a relatively large area between Flemish Cap and the Grand Bank, and such a dynamic formation gave rise to northerly current on the west side of the Cap and a southerly set on the east side of the Bank. About 50 miles northeast of the Tail we located a comparatively small circular depression which gave the dynamic topography in this vicinity an odd appearance. The water between the 50 and 100 fathom curves, on the northeastern part of the Bank, where the slope of the bottom is

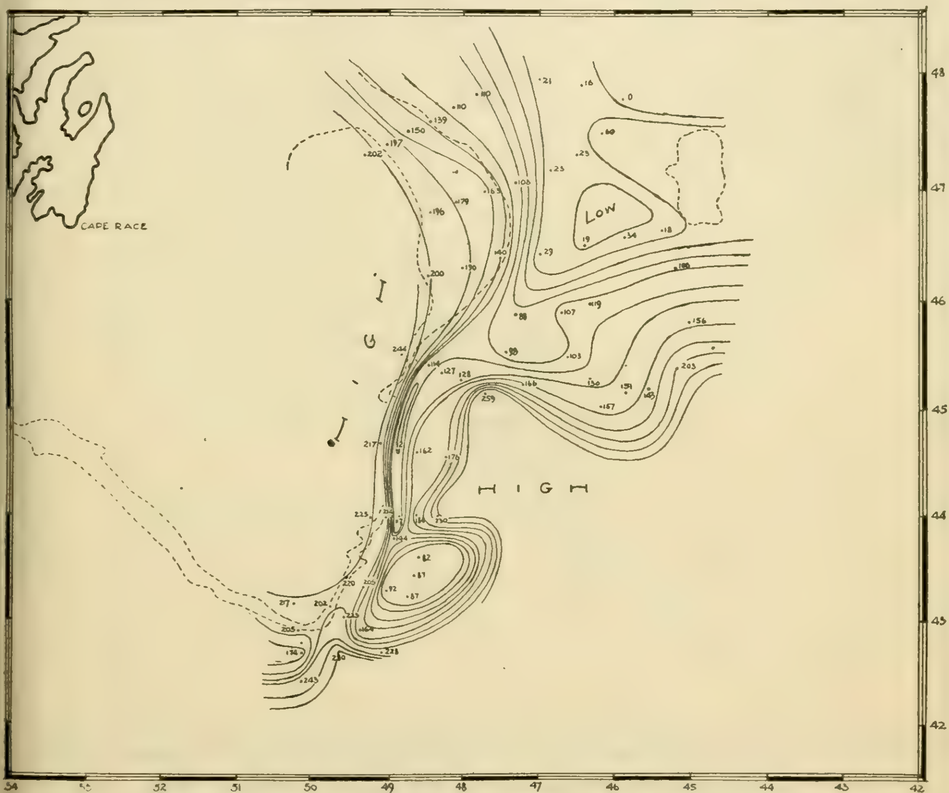

FIG. 49.—Set V. Dynamic topographic map drawn from observations made at stations 770–839, June 9–25, 1927. It is read the same as an ordinary isobaric weather map

gradual, formed the general limits of a wide gently flowing current, which, however, after crossing the forty-sixth parallel, narrowed and correspondingly increased in velocity. Sixty miles farther south the constriction became still further marked, and the rapid flow of 1.4 knots per hour was recorded between the forty-fourth and forty-fifth parallels along the continental edge. Casting our eyes farther south, we find the inner current, however, was apparently mostly all turned back before reaching the Tail, but lacking data from the southwest slope permits no definite statement.

The anticlockwise eddy seen on Figure 50, about 45 miles northeast of the Tail, is an excellent example of a process often to be found along the boundary of two opposing marine flows. We have noted before that when the Labrador current, which hugs the slope, becomes constricted and attenuated, no continuous, uninterrupted streaming of it can possibly prevail. On the other hand, it characteristically is broken up into a chain of eddies and regional circuits, distributed along the continental edge.

FIG. 50.—Set V. The direction and velocity of the currents, June 9–25, 1927. The drift of two bergs is shown from June 11–21, 1927

The outer current between the forty-fourth and forty-fifth parallels, June 9 to 25, swept in very close to the eastern edge of the Grand Bank, its inner edge at one place being only 5 miles in the offing. The current from there ran due north to latitude 45°, longitude 47° 35′, and then was bent back to the southeast, apparently by a discharge from northern regions between the Bank and the Cap. The outer current after passing this vent recurved toward the northeast, and finally proceeded out of our picture immediately south of Flemish Cap.

Examination of the temperature and salinity maps (figs. 51 and 52) plainly shows that the currents along the eastern slope of the Grand Bank were composed of two distinctly different types of water. The relatively cold and fresh masses which hugged the 100-fathom curve belong to the Labrador current, while the warm salty water flowing in the opposite direction was that commonly associated with the Gulf Stream. Along the boundary of the currents eddies and sinuous shapes characterized the general behavior.

FIG. 51.—Set V. The distribution of warm and cold water at the 50-meter level, June 9–25, 1927

The patrol was especially interested in following the drift of two bergs which were sighted on the 11th of June floating in the Labrador current on the northeastern part of the Grand Bank. They were seen again on the 17th, 80 miles farther south, a drift which agrees very well with the velocity and the direction of the current as calculated and shown on Figure 50. The ice was sighted for the last timo on June 21, having drifted southeasterly in the four days interim at the rate of 0.4 of a knot per hour. This set does not agree so well with the results obtained from observations in that locality, where the patrol found only a weak and variable tendency toward an easterly

circulation. The explanation of disagreement may lie in a sudden and transitory outpush of water from between the Grand Bank and Flemish Cap. The shape of the stream lines on the inner side of the Gulf Stream in this locality suggest such a possibility.

SUMMARY

The five current surveys which were made of the waters around the Grand Bank beginning the first week in April and ending the latter

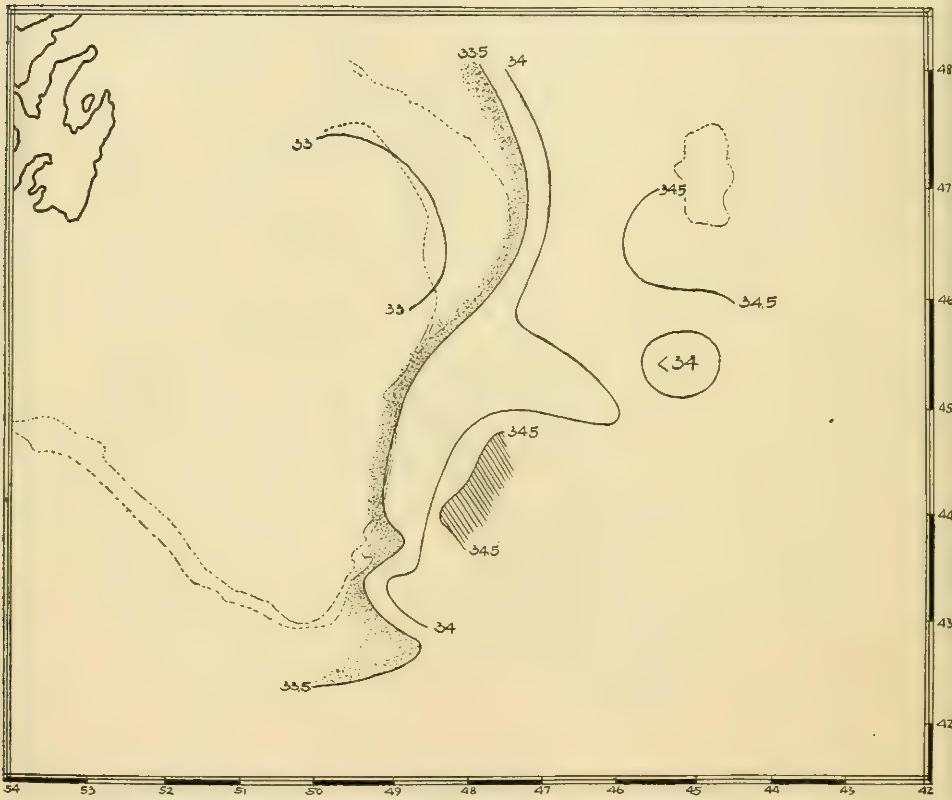

Fig. 52.—Set V. The distribution of salinity at the 50-meter level, June 9–25, 1927

part of June (and the five sets of illustrations, figs. 33–52) permit us to follow quite accurately the changes in the general circulation which took place during the ice season of 1927.

When the patrol vessel first entered the ice regions the circulatory system was basically normal, and by that is meant, Labrador current flowed southward along the eastern edge of the Grand Bank, while offshore the Gulf Stream moved eastward in the Atlantic. The counterclockwise eddy that the patrol has so often observed centered over the southwestern slope of the Grand Bank was sounded out and

charted soon after our arrival. The only unusual feature in early April was the wavelike form to the northern edge of the Gulf Stream southwest of the Tail, indicating a tendency of the warm current to invade the zone of mixed water. This particular feature developed during the latter part of the month, splitting the current, warm water lying both inshore and offshore of cold. We first observed the latter part of April that warm salty water was working inshore, up the submarine valley which lies near the forty-fourth parallel, on the east side of the Grand Bank. The outer current continued to encroach in toward the continental edge throughout the next two months, sometimes being pressed right up against the 100-fathom contour, effectively blocking any opportunity for ice to drift past. The outer current also swept northward along the eastern face of the Grand Bank as far as latitude 45° 00′ before it was completely deflected offshore passing south of Flemish Cap.

The Labrador current, on the other hand, during the last two months of the ice season was confined to a narrow stream along the east side of the Bank, which hugged the slope, was continually being turned back by the outer current, and seldom reached farther south than the Tail. The Labrador current tended to discharge at various times throughout the season considerable masses of cold water between the Grand Bank and Flemish Cap, and this fact is witnessed in the receding form to the inner side of the Gulf Stream where it passed this vent.

The foregoing facts mark 1927 as the first ice season throughout which the general behavior of the water masses at the junction of the Labrador current and the Gulf Stream has been accurately followed.

The drift of the icebergs in 1927, as might naturally be expected from the above, conformed to the developments in the circulation. Only one berg during the season succeeded in drifting along the normal path to the Tail, and that incident occurred before the middle of April. The few bergs that later were transported as far south as the forty-fourth parallel came under the influence of the onshore set, and either were swept to the westward into shoal water or were wheeled back to the northeast, along with much of the cold current.

As a result of the foregoing it is plain to see that frequent surveys of the currents around the Atlantic faces of the Grand Bank furnish an intelligent insight regarding the probable drift of the ice, and when carried out by the ice patrol such as in 1927, insures far greater safety to the trans-Atlantic steamships.

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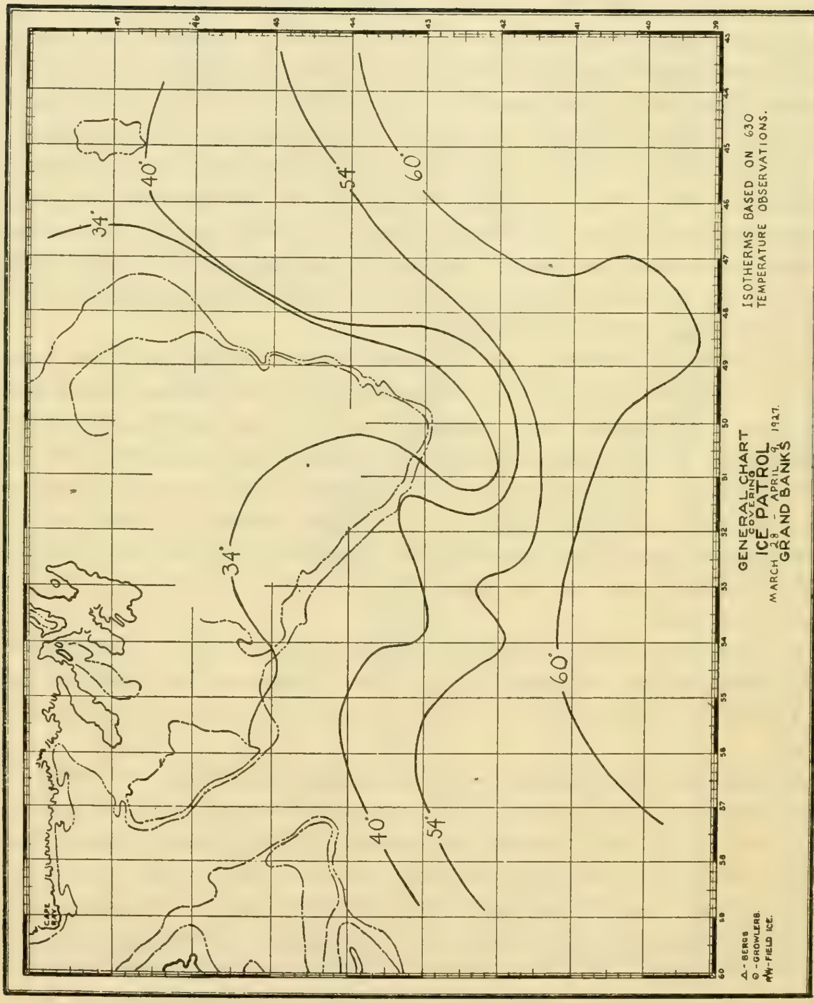

FIG. 53.—Surface temperature, March 28–April 9, 1927

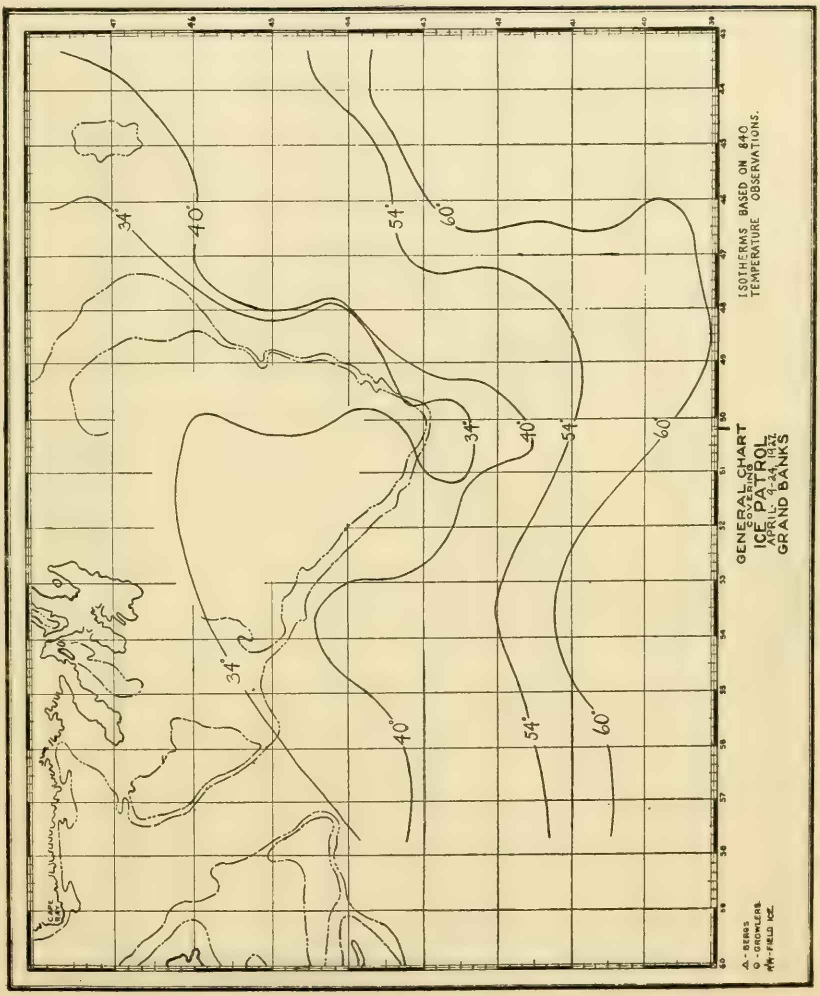

FIG. 54.—Surface temperature, April 9–24, 1927

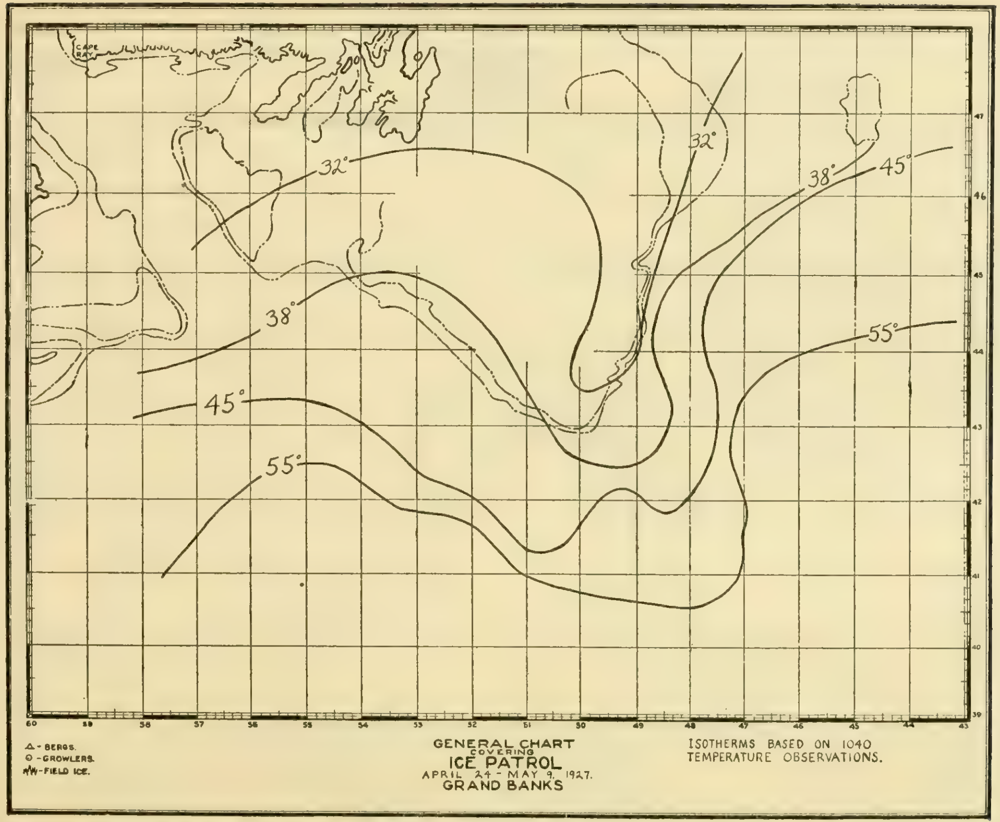

FIG. 55.—Surface temperature, April 24–May 9, 1927

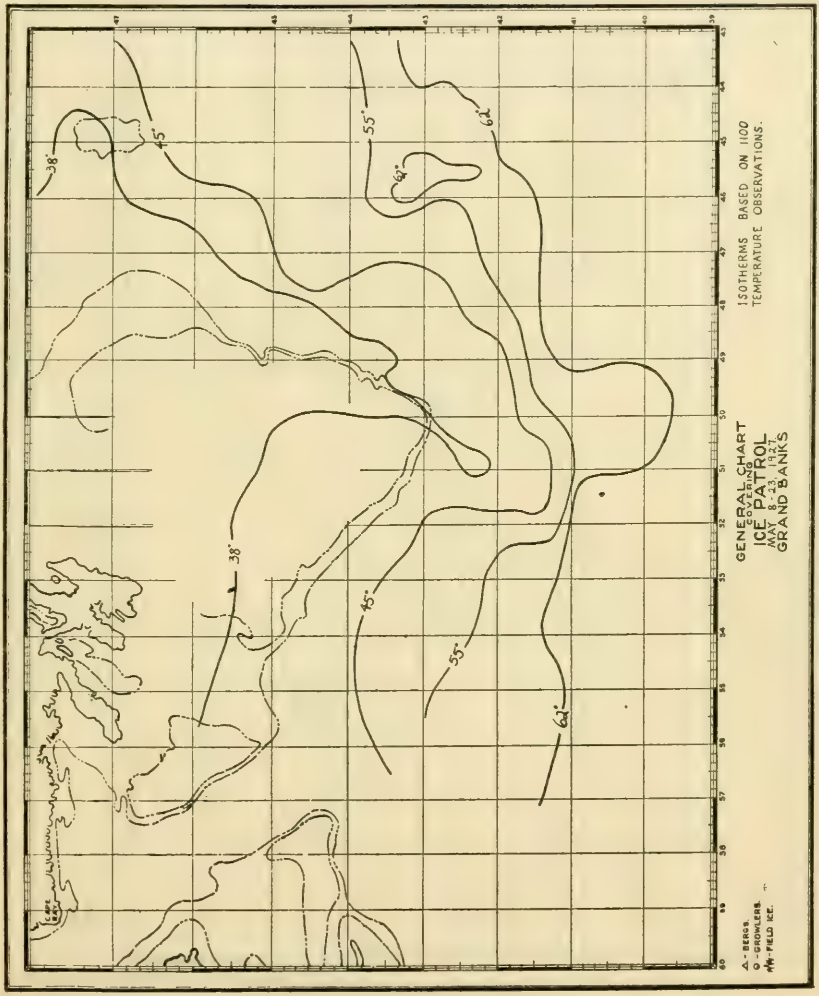

FIG. 56.—Surface temperature, May 8-23, 1927

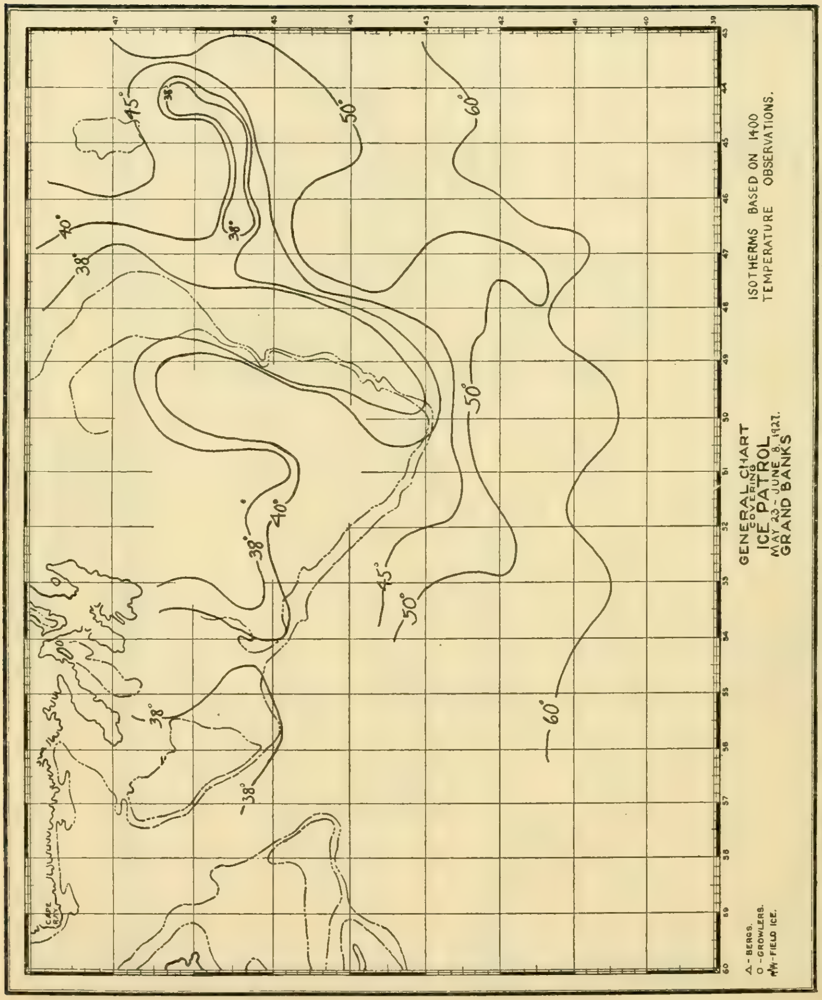

FIG. 57.—Surface temperature, May 23–June 8, 1927

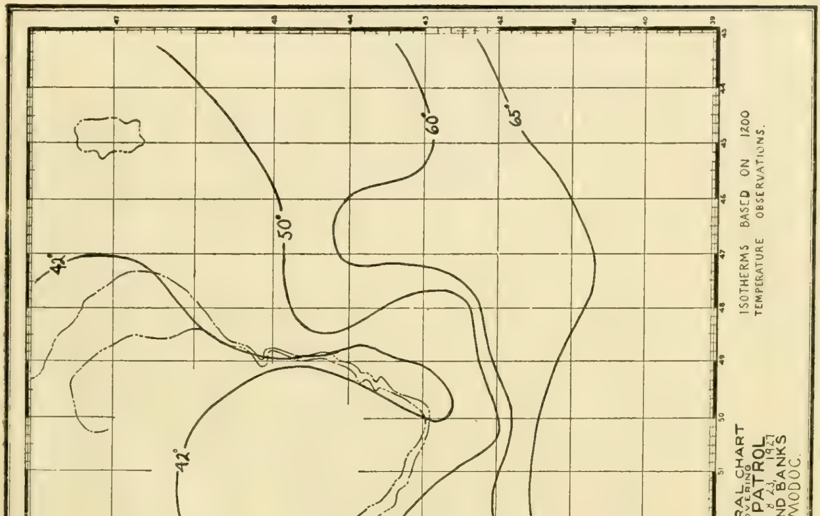

FIG. 58.—Surface temperature, June 8–23, 1927

OCEANOGRAPHIC STATION DATA AND DYNAMIC CALCULATIONS, 1927

δ_t at head of column 9 represents the value, density.
V at head of column 10 represents the value, specific volume in situ.
$V-V_1$ at head of column 11 represents the value, anomaly of specific volume in situ.
E at head of column 12 represents the value, height in dynamic meters.
$E-E_1$ at head of column 13 represents the value, anomaly of dynamic height.

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	Temperature (a=Meters)	Salinity 0/00 (a=Meters)	δ_t (a=Meters)	V (a_1=Pressure in decibars)	$V-V_1$ (a_1=Pressure in decibars)	E (a_1=Pressure in decibars)	$E-E_1$ (a_1=Pressure in decibars)
		° ′	° ′			°C.						
631	Apr. 6	42 47	49 39	1,920	0	0.1	33.59	26.99	0.97372	108	0	0
					25	−.2	33.59	27.00	.97360	107	24.34250	.02785
					50	−.2	33.61	27.01	.97347	105	48.67988	.05338
					125	.6	33.98	27.26	.97291	83	121.66913	.12401
					250	1.8	34.38	27.51	.97212	60	243.23351	.21352
					450	3.2	34.72	27.66	.97110	48	437.75551	.52202
					750	4.0	34.90	27.73	.96969	40	728.87401	.65452
632	do	42 45	49 24	2,190	0	.6	33.71	27.06	.97366	102	0	0
					25	.4	33.72	27.07	.97354	101	24.34000	.02535
					50	.3	33.83	27.17	.97332	90	48.67575	.04925
					125	.2	34.17	27.45	.97272	64	121.65225	.10713
					250	2.2	34.41	27.50	.97213	61	243.20475	.18476
					450	3.8	34.80	27.67	.97110	48	437.52675	.29326
					750	3.6	34.82	27.71	.96975	46	728.65275	.43326
633	Apr. 7	43 23	49 22	1,190	0	.7	35.58	26.87	.97383	119	0	0
					25	.2	33.70	27.06	.97355	102	24.34225	.02750
					50	.6	33.87	27.17	.97332	90	48.67800	.05150
					125	1.0	33.92	27.20	.97296	88	121.66350	.11838
					250	1.2	34.11	27.34	.97228	76	243.24100	.22101
					450	2.0	34.41	27.52	.97123	61	437.59100	.35751
					750	3.0	34.63	27.61	.96982	53	728.74700	.52751
634	do	43 21	49 03	1,325	0	2.4	34.36	26.56	.97413	149	0	0
					25	1.2	33.28	26.67	.97391	138	24.35050	.03585
					50	1.1	33.38	26.75	.97371	129	48.69575	.06925
					125	3.2	34.40	27.41	.97277	69	121.68500	.13988
					250	3.4	34.68	27.62	.97201	49	243.23375	.21376
					450	3.6	34.80	27.69	.97108	46	437.54175	.30826
					750	3.7	34.84	27.71	.96975	46	728.66475	.44526
635	do	43 20	48 42	1,143	0	4.0	33.29	26.45	.97423	159	0	0
					25	3.6	33.41	26.58	.97400	147	24.35275	.03810
					50	2.6	33.36	26.63	.97383	141	48.69625	.06975
					125	2.4	34.14	27.29	.97289	81	121.69825	.15313
					250	4.6	34.83	27.60	.97205	53	243.25700	.23701
					450	4.2	34.84	27.67	.97110	48	437.57100	.33751
					750	4.0	34.90	27.73	.96973	44	728.70400	.48451
636	do	43 23	48 18	2,745	0	3.9	33.72	26.81	.97389	125	0	0
					25	7.2	34.41	26.94	.97376	123	24.34425	.02960
					50	7.4	34.45	26.95	.97353	111	48.68400	.05750
					125	4.8	34.86	27.21	.97296	88	121.63425	.08913
					250	5.6	34.81	27.47	.97218	66	243.20550	.18551
					450	4.6	34.86	27.59	.97118	56	437.54150	.30801
					750	3.9	34.87	27.72	.96974	45	728.67950	.46001
637	do	43 02	48 22	1,850	0	2.6	33.32	26.60	.97409	145	0	0
					25	1.8	33.39	26.71	.97387	134	24.34950	.03485
					50	2.6	33.51	26.75	.97371	129	48.69425	.06775
					125	3.0	34.39	27.42	.97276	68	121.70188	.15676
					250	4.0	34.76	27.62	.97202	50	243.24938	.22939
					450	4.1	34.90	27.72	.97105	43	437.55638	.32289
					750	[1] 3.8	34.87	27.72	.96974	45	728.67488	.45539
638	Apr. 8	42 41	48 23	2,710	0	3.2	33.25	26.57	.97412	148	0	0
					25	2.8	33.58	26.79	.97380	147	24.34900	.03435
					50	2.7	33.59	26.80	.97367	125	48.69237	.06587
					125	2.9	34.21	27.28	.97290	82	121.70374	.15862
					250	3.8	34.68	27.62	.97202	50	243.26124	.24125
					450	4.2	34.86	27.67	.97110	48	437.57324	.33975
					750	3.9	34.89	27.73	.96973	44	728.69749	.47795
639	do	42 40	48 52	2,140	0	1.8	33.60	26.88	.97382	118	0	0
					25	1.4	33.57	26.88	.97371	118	24.34412	.02947
					50	1 6	33 73	27.00	.97348	106	48.68399	.05749
					125	1.0	33.82	27.11	.97305	97	121.69386	.14874
					250	2.6	34.53	27 56	.97208	56	243.26449	.24450
					450	3.8	34.82	27.68	.97109	47	437.58149	.34800
					750	3.6	34.86	27.74	.96971	42	728.78149	.56200
640	do	42 51	49 37	1,080	0	0	33.70	26.67	97402	138	0	0
					25	−.8	33.28	26.77	.97382	129	24.34800	.03335
					50	−.6	33.48	26.92	97354	112	48.69012	.06362
					125	.7	33.95	27.23	.97324	116	121.65724	.11212
					250	1.4	34.19	27.39	.97223	71	243.24911	.22912
					450	2.8	34.60	27.56	.97119	57	437.59111	.35712
					750	3.3	34.74	27.66	.96978	49	728.73661	.56712

[1] Interpolated

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	a=Meters: δ_t	a_1=Pressure in decibars: V	a_1=Pressure in decibars: $V-V_1$	a_1=Pressure in decibars: E	a_1=Pressure in decibars: $E-E_1$
		° ′	° ′			°C.						
641	Apr. 8	42 50	50 24	980	0	−.2	33.09	26.60	0.97409	145	0	0
					25	−.4	33.20	26.69	.97389	136	24.34975	.03510
					50	−1.0	33.24	26.74	.97372	130	48.69487	.06837
					125	−.8	33.44	26.90	.97324	116	121.70587	.16075
					250	.8	33.99	27.26	.97235	83	243.30524	.28525
					450	2.8	34.23	27.30	.97144	82	437.67424	.44075
					750	3.6	34.72	27.62	.96982	53	728.87324	.65375
642	Apr. 9	43 02	51 14	1,520	0	3.6	32.57	25.92	.97473	209	0	0
					25	3.6	32.85	26.13	.97442	189	24.36437	.04972
					50	5.4	33.43	26.41	.97404	162	48.72012	.09362
					125	6.0	34.38	27.08	.97310	102	121.73787	.19275
					250	4.2	34.44	27.34	.97229	77	243.32474	.30475
					450	5.2	34.88	27.56	.97122	60	437.67574	.44225
					750	3.8	34.80	27.66	.96979	50	728.82724	.60775
643	do	43 06	52 01	940	0	1.4	32.36	25.85	.97480	216	0	0
					25	5.0	33.30	26.35	.97421	168	24.36262	.04797
					50	8.0	34.21	26.68	.97379	137	48.71262	.08612
					125	11.7	35.25	26.85	.97331	123	121.72887	.18375
					250	8.8	34.99	27.16	.97248	96	243.34074	.32075
					450	4.3	34.68	27.52	.97124	62	437.71274	.47925
					750	4.1	34.85	27.67	.96979	50	728.71724	.49775
644	do	42 40	52 23	3,430	0	7.6	34.08	26.63	.97406	142	0	0
					25	7.4	34.08	26.64	.97394	141	24.35000	.03535
					50	7.8	34.10	26.66	.97381	139	48.69687	.07037
					125	11.2	35.09	26.83	.97333	125	121.71462	.16950
					250	9.8	35.14	27.11	.97254	102	243.33149	.31150
					450	3.2	[1] 34.50	27.48	.97127	65	437.71249	.47900
					750	3.6	34.75	27.64	.96980	51	728.87299	.65350
645	do	42 33	51 20	2,320	0	5.1	33.10	26.18	.97449	185	0	0
					25	6.0	33.66	26.52	.97405	152	24.35675	.04210
					50	10.4	34.80	26.74	.97373	131	48.70400	.07750
					125	11.1	35.10	26.85	.97331	123	121.71800	.17288
					250	[1] 10.1	35.10	27.02	.97262	110	243.33862	.31863
					450	6.8	34.75	27.27	.97152	90	437.75262	.51913
					750	4.0	34.71	27.60	.96982	53	728.95362	.73413
646	do	42 12	51 31	2,920	0	6.0	34.16	26.62	.97407	143	0	0
					25	6.1	34.41	26.66	.97392	139	24.34813	.03348
					50	10.0	34.66	26.70	.97377	135	48.69426	.06776
					125	11.4	35.15	26.83	.97333	125	121.71051	.16439
					250	11.2	35.21	26.92	.97272	120	243.33864	.31865
					450	7.6	34.81	27.20	.97163	101	437.77364	.54015
					750	3.6	34.75	27.45	.96999	70	729.00913	.78964
647	Apr. 10	41 50	51 47	3,870	0	14.4	35.81	26.73	.97396	132	0	0
					25	14.4	35.81	26.73	.97385	132	24.34762	.03287
					50	14.4	35.80	26.74	.97373	131	48.69237	.06587
					125	14.0	35.71	26.75	.97341	133	121.71012	.16500
					250	11.6	35.38	26.97	.97268	116	243.34087	.32088
					450	7.2	34.74	27.20	.97157	95	437.76587	.53238
					750	5.4	34.77	27.46	.97000	71	729.00137	.78188
648	do	41 37	50 13	3,720	0	12.3	35.19	26.70	.97399	135	0	0
					25	12.2	35.20	26.72	.97386	133	24.34812	.03347
					50	12.2	35.24	26.75	.97372	130	48.69287	.06637
					125	12.2	35.11	26.96	.97321	113	121.70275	.15763
					250	11.2	35.38	27.11	.97255	103	243.31275	.21276
					450	8.8	34.48	27.35	.97145	83	437.71275	.47926
					750	4.6	34.75	27.57	.96989	60	728.91375	.69426
649	do	41 58	50 15	3,720	0	10.4	34.68	26.65	.97404	140	0	0
					25	11.3	34.90	26.66	.97392	139	24.34950	.03485
					50	11.6	35.09	26.75	.97372	130	48.69750	.07100
					125	10.6	35.26	27.05	.97312	104	121.70400	.15888
					250	8.6	34.94	27.15	.97250	98	243.30525	.28526
					450	6.2	34.78	27.37	.97140	78	437.69525	.46176
					750	4.4	34.85	27.64	.96982	53	728.87825	.65876
650	do	42 22	50 16	2,850	0	0.8	33.19	26.62	.97407	143	0	0
					25	0.1	33.35	26.79	.97380	127	24.34838	.03373
					50	0.0	33.50	26.92	.97355	113	48.69026	.06376
					125	1.2	33.90	27.16	.97301	93	121.68626	.14114
					250	2.8	34.27	27.33	.97229	77	243.26751	.24752
					450	4.2	34.81	27.63	.97113	51	437.60951	.37602
					750	4.2	34.89	27.70	.97042	13	728.84201	.62252
651	Apr. 12	42 45	49 58	5,470	0	2.2	33.16	26.50	.97418	154	0	0
					25	−0.8	33.12	26.64	.97394	141	24.35150	.03685
					50	−0.6	33.32	26.80	.97367	125	48.69650	.07000
					125	0.0	33.72	27.09	.97307	99	121.69925	.15413
					250	1.3	33.93	27.18	.97243	91	243.29300	.27301
					450	2.5	34.39	27.46	.97129	67	437.61100	.37751
					750	3.5	34.57	27.51	.96993	64	728.79400	.57451

[1] Interpolated

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	Temperature (a = Meters)	Salinity 0/00 (a = Meters)	δ_t (a = Meters)	V (a_1 = Pressure in decibars)	V−V_1	E	E−E_1
		° ′	° ′			°C.						
652	Apr. 21	43 37	49 38	61	0	0	33.19	26.67	0.97402	------	0	0
					14	−0.4	33.19	26.69	.97393	------	------	------
					28	−0.8	33.19	26.70	.97385	------	------	------
					42	−0.8	33.24	26.74	.97376	------	------	------
					50	−0.7	33.26	26.75	.97371	129	48.53527	------
					56	−0.7	33.26	26.75	.97369	------	------	------
653	do	43 22	49 22	168	0	6.8	34.08	26.75	.97394	130	0	0
					25	7.9	34.42	26.86	.97373	120	24.34563	.03098
					50	7.7	34.59	27.02	.97347	105	48.68558	.05908
					125	10.2	35.13	27.04	.97313	105	121.68308	.13796
					250	8.4	34.90	27.15	.97249	93	243.28433	.26434
					450	9.2	34.85	27.47	.97133	72	237.66733	.43384
					750	4.8	34.81	27.57	.96990	63	728.85333	.63384
654	do	43 17	49 13	1,170	0	8.8	34.62	26.87	.97383	119	0	0
					25	8.8	34.68	26.42	.97367	114	24.34375	.03910
					50	8.4	34.67	26.97	.97352	110	48.68362	.05712
					125	8.6	34.80	27.04	.97313	105	121.68299	.13787
					250	8.8	34.94	27.12	.97253	101	243.21174	.19175
					450	5.1	34.36	27.17	.97158	96	437.62274	.38925
					750	4.4	34.60	27.44	.97011	72	728.86124	.64175
655	Apr. 22	43 13	49 00	1,170	0	8.0	33.86	26.40	.97426	164	0	0
					25	8.0	33.93	26.46	.97412	158	24.35487	.04022
					50	7.7	34.45	26.90	.97363	116	48.70099	.07449
					125	7.5	34.51	26.98	.97305	111	121.70486	.15974
					250	7.8	34.67	27.06	.97229	105	243.31486	.29487
					450	6.4	34.67	27.28	.97116	87	437.72096	.48747
					750	4.0	34.62	27.50	.97977	66	728.93686	.71737
656	do	43 09	48 43	1,650	0	5.6	33.47	26.42	.97418	162	0	0
					25	5.6	33.50	26.45	.97384	159	24.35475	.04010
					50	5.4	33.99	26.85	.97357	121	48.70162	.07512
					125	5.8	34.40	27.13	.97302	97	121.70212	.15700
					250	6.2	34.75	27.35	.97221	87	243.28587	.26588
					450	5.1	34.77	27.61	.97110	54	437.63087	.39738
					750	4.5	34.94	27.70	.97968	48	728.78037	.56088
657	do	42 36	48 50	2,910	0	3.0	33.24	26.50	.97418	154	0	0
					25	3.0	33.51	26.74	.97384	131	24.35025	.03560
					50	3.4	33.78	26.90	.97357	115	48.69288	.06638
					125	3.5	34.11	27.15	.97302	94	121.69001	.14489
					250	4.8	34.64	27.43	.97221	69	243.26626	.24627
					450	[1] 4.5	34.90	27.66	.97110	48	437.59625	.36276
					750	4.2	35.00	27.78	.97968	39	728.71326	.49377
658	do	42 41	49 20	2,010	0	0.2	33.29	26.73	.97396	132	0	0
					25	0.2	33.29	26.73	.97385	132	24.34763	.03298
					50	0.1	[1] 33.40	26.78	.97367	127	48.69188	.06538
					125	7.7	34.63	27.03	.97314	104	121.69801	.15289
					250	6.2	34.53	27.17	.97247	95	243.29864	.27865
					450	2.5	34.36	27.40	.97137	75	437.68264	.44915
					750	2.4	34.68	27.70	.96976	47	728.85214	.63265
659	do	42 52	49 44	650	0	7.4	34.26	26.80	.97390	126	0	0
					25	7.4	34.30	26.83	.97376	123	24.34575	.03110
					50	9.2	34.80	26.95	.97353	111	48.68688	.06038
					125	8.3	34.83	27.12	.97306	98	121.68401	.13889
					250	6.0	34.67	27.31	.97234	82	243.27159	.25160
					450	4.4	34.72	27.54	.97122	60	437.62751	.49408
					750	3.5	34.83	27.72	.96973	44	728.77001	.55052
660	Apr. 23	42 31	50 47	2,520	0	0.2	33.29	26.73	.97396	132	0	0
					25	0.2	33.29	26.73	.97385	132	24.34763	.03298
					50	0.1	[1] 33.40	26.78	.97369	127	48.69188	.06538
					125	7.7	34.63	27.03	.97314	106	121.69801	.15289
					250	6.2	34.53	27.17	.97247	95	243.29864	.27865
					450	2.5	34.36	27.40	.97137	75	437.68234	.44915
					750	2.4	34.68	27.70	.96976	47	728.85214	.63265
661	do	42 35	51 15	1,960	0	5.8	33.33	26.28	.97439	175	0	0
					25	5.8	33.34	26.29	.97427	185	24.35825	.04360
					50	6.3	33.35	26.40	.97406	198	48.71238	.08588
					125	8.2	34.63	26.97	.97319	167	121.73426	.18914
					250	8.0	34.98	27.28	.97237	105	243.33176	.31167
					450	5.1	34.81	27.53	.97124	62	437.69376	.46027
					750	4.2	34.85	27.67	.96978	27	728.84676	.62727
662	do	42 21	51 33	3,350	0	6.8	33.63	26.39	.97429	165	0	0
					25	6.8	33.79	26.51	.97406	153	24.35438	.03973
					50	7.7	34.13	26.66	.97381	139	48.70275	.07625
					125	11.4	35.16	26.85	.97331	123	121.79476	.14964
					250	[1] 9.2	[1] 35.10	27.10	.97255	103	243.41103	.39102
					450	4.9	[1] 34.62	27.40	.97136	74	437.80201	.56852
					750	4.6	34.90	27.65	.96982	53	728.97901	.75952

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	a=Meters: δ_t	a_1=Pressure in decibars: V	a_1=Pressure in decibars: V−V$_1$	a_1=Pressure in decibars: E	a_1=Pressure in decibars: E−E$_1$
		° ′	° ′			°C.						
663	Apr. 23	42 00	51 50	3,470	0	6.4	33.64	26.50	0.97418	154	0	0
					25	6.4	33.45	26.61	.97397	144	24.35188	.03723
					50	6.4	33.94	26.68	.97378	136	48.69867	.07226
					125	10.6	34.89	26.78	.97338	130	121.71726	.17214
					250	[1]9.5	34.93	27.00	.97273	121	243.34914	.32915
					450	6.0	34.62	27.27	.97150	98	437.77214	.53865
					750	4.4	34.71	27.53	.96992	63	728.98889	.76565
664	Apr. 24	42 35	52 26	3,420	0	5.8	33.26	26.22	.97445	181	0	0
					25	5.8	33.52	26.42	.97415	162	24.35750	.04285
					50	6.0	33.95	26.53	.97373	131	48.70600	.07590
					125	11.4	35.04	26.70	.97326	108	121.71813	.17301
					250	[1]9.6	35.04	27.07	.97257	105	243.33251	.31252
					450	6.1	34.62	27.26	.97151	89	437.74051	.50702
					750	4.6	34.88	27.65	.96982	53	728.94001	.72052
665	do	43 03	53 20	3,110	0	6.7	33.55	26.34	.97433	169	0	0
					25	7.1	33.77	26.45	.97412	159	24.35563	.04098
					50	10.9	34.78	26.50	.97396	154	48.70663	.08013
					125	12.6	35.24	26.68	.97348	130	121.73563	.19051
					250	10.5	35.23	27.06	.97259	107	243.36501	.31802
					450	5.2	34.67	27.41	.97135	73	437.75901	.52552
					750	4.6	34.90	27.66	.96982	54	728.93451	.71502
666	do	43 10	52 37	2,260	0	5.2	32.98	26.07	.97459	195	0	0
					25	5.2	33.07	26.14	.97441	188	24.36250	.04785
					50	5.4	33.76	26.66	.97380	138	48.71513	.08853
					125	10.2	35.03	26.95	.97321	113	121.72801	.18289
					250	6.3	34.91	27.46	.97219	67	243.31551	.29552
					450	5.5	34.93	27.58	.97119	57	437.65351	.42002
					750	4.0	34.98	27.79	.96967	38	728.78251	.56302
667	do	43 29	51 56	950	0	2.4	33.06	26.41	.97427	163	0	0
					25	2.2	33.07	26.43	.97414	161	24.35514	.04048
					50	2.4	33.18	26.50	.97395	153	48.70626	.08076
					125	5.2	[1]33.96	26.90	.97325	117	121.72626	.18114
					250	[1]4.3	[1]34.40	27.30	.97233	81	243.32501	.30502
					450	3.7	[1]34.70	27.58	.97118	56	437.67601	.44252
					750	[1]4.0	34.94	27.76	.96969	40	728.8081	.58852
668	Apr. 25	43 05	51 35	620	0	4.4	33.00	26.18	.97449	185	0	0
					25	4.2	33.12	26.30	.97426	173	24.35938	.04473
					50	4.2	33.30	26.44	.97401	159	48.71276	.08626
					125	4.2	34.01	27.00	.97316	108	121.73164	.18652
					250	4.2	34.51	27.40	.97223	71	243.31852	.29853
					450	4.6	34.86	27.63	.97114	52	437.65552	.42203
					750	4.0	35.06	27.85	.96961	32	728.76812	.44863
669	do	42 56	51 00	1,080	0	5.2	33.22	26.26	.97441	177	0	0
					25	4.4	33.64	26.68	.97390	137	24.35263	.03798
					50	8.1	34.49	26.88	.97360	118	48.69738	.07088
					125	9.0	34.87	27.03	.97314	106	121.70013	.15501
					250	7.2	34.75	27.22	.97242	90	243.29763	.27764
					450	4.8	34.64	27.13	.97133	71	437.62263	.43914
					750	4.0	34.83	27.67	.96979	50	728.84063	.62114
670	do	42 51	50 16	800	0	0.4	33.21	26.66	.97403	139	0	0
					25	0.4	33.23	26.68	.97390	137	24.34913	.03448
					50	−0.2	33.27	26.74	.97372	130	48.69438	.06788
					125	0.2	33.62	27.00	.97314	106	121.70201	.15689
					250	1.0	33.83	27.12	.97249	97	243.30451	.28452
					450	2.2	34.24	27.37	.97137	75	437.69051	.45702
					750	2.6	34.73	27.75	.96967	38	728.84651	.62702
671	do	42 35	50 19	2,270	0	2.6	33.43	26.68	.97401	137	0	0
					25	3.9	33.64	26.74	.97384	131	24.34813	.03348
					50	7.0	34.48	27.03	.97346	104	48.68937	.06287
					125	6.4	[1]34.67	27.21	.97297	89	121.68051	.13539
					250	5.3	34.61	27.35	.97229	77	243.26026	.25027
					450	4.6	34.57	27.44	.97132	70	437.62126	.38777
					750	3.8	34.68	27.58	.96987	58	728.79876	.57927
672	do	42 17	50 18	2,845	0	10.6	34.79	26.70	.97399	134	0	0
					25	11.2	35.07	26.81	.97378	125	24.34713	.03248
					50	11.4	35.15	26.84	.97364	122	48.68988	.06338
					125	11.6	35.26	26.89	.97338	120	121.71313	.16801
					250	8.6	34.86	27.00	.97256	104	243.32438	.20439
					450	5.1	34.78	27.51	.97126	64	437.90638	.67289
					750	4.2	34.82	27.65	.96980	51	729.06538	.84589

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	δ_t	a_1=Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C.						
673	Apr. 25	41 57	50 18	3,720	0	4.0	33.45	26.58	0.97411	147	0	0
					25	3.2	33.30	26.58	.97400	147	24.35138	.03673
					50	1.2	33.38	26.75	.97371	129	48.69775	.07125
					125	4.4	34.36	27.33	.97285	77	121.69375	.14863
					250	5.8	34.28	27.42	.97222	72	243.26075	.24076
					450	4.7	34.84	27.60	.97117	55	437.59975	.36626
					750	4.0	34.86	27.70	.96976	47	728.73925	.51976
674	Apr. 29	42 46	49 51	2,090	0	5.0	33.72	26.67	.97402	138	0	0
					25	4.6	33.68	26.69	.97389	136	24.34888	.03423
					50	4.6	33.90	26.87	.97360	118	48.69251	.06601
					125	3.9	34.20	27.18	.97299	91	121.68964	.14452
					250	3.8	34.59	27.50	.97214	62	243.26027	.24028
					450	3.6	34.80	27.69	.97108	46	437.58227	.35878
					750	3.6	[1]34.84	27.72	.96973	44	728.70377	.48428
675	do	42 56	49 54	238	0	7.6	34.15	26.68	.97401	------	0	0
					25	7.6	34.18	26.71	.97386	------	------------	-------
					50	9.4	34.72	26.85	.97363	121	48.69201	.06551
					125	7.1	34.70	27.19	.97299	------	------------	-------
					225	5.0	34.50	27.30	.97244	------	------------	-------
					250	4.1	34.44	27.35	.97228	76	243.27576	.25577
676	do	43 08	50 01	54	0	1.4	33.21	26.60	.97409	145	0	0
					13	1.1	33.11	26.65	.97398	140	12.66246	.01849
					26	6.0	34.05	26.82	.97377	124	25.32284	-------
					39	5.7	33.96	26.92	.97359	113	37.98078	-------
					50	------	-------	26.95	.97353	111	48.68984	.06334
					52	5.4	34.12	26.95	.97352	111	------------	-------
677	do	43 16	50 16	59	0	0.4	33.11	26.58	.97411	147	0	0
					15	0.4	33.21	26.66	.97396	139	14.59553	.00639
					30	0.0	33.19	26.67	.97388	137	29.19433	.01708
					45	0.0	33.27	26.73	.97375	131	43.80156	.03721
					50	0.0	33.30	26.78	.97369	127	48.68016	.05366
					60	0.1	33.36	26.80	.97353	116	------------	-------
678	May 10	46 04	48 38	79	0	0.8	32.99	26.46	.97422	158	0	0
					20	0.6	33.00	26.48	.97411	156	19.48330	.03135
					40	0.4	33.02	26.51	.97398	152	38.96150	.05940
					50	−1.0	-------	26.56	.97390	148	48,70360	.07710
					60	−0.2	33.12	26.62	.97380	143	58.44030	.08985
					80	−1.1	33.13	26.75	.97358	130	77.91590	.11890
					100	------	-------	-------	.97331	112	97.38490	.14315
679	do	46 00	48 21	119	0	1.4	32.92	26.37	.97431	167	0	0
					25	0.0	32.92	26.45	.97423	170	24.35538	.04072
					50	−1.2	33.08	26.63	.97406	164	48.70475	.07825
					75	−1.4	33.24	26.76	.97394	163	73.04762	.11209
					100	−1.4	33.32	26.82	.97388	169	97.38550	.14375
					[2] 125	------	-------	26.84	.97386	178	121.71962	.17451
680	do	45 56	48 00	183	0	0.6	32.69	26.23	.97444	180	0	0
					30	−0.6	33.00	26.54	.97400	149	29.22660	.04935
					60	−1.6	33.28	26.80	.97363	126	58.44105	.09060
					90	−1.7	33.37	26.87	.97342	118	87.64680	.12720
					120	−1.4	33.56	27.02	.97324	114	116.84670	.16225
					125	−0.4	-------	27.02	.97313	105	121.71262	.17750
					150	−1.4	33.58	27.04	.97299	102	146.03912	.19338
681	do	45 52	47 41	1,097	0	1.4	32.78	26.25	.97442	178	0	0
					25	−0.8	33.27	26.74	.97384	131	24.35325	.03860
					50	−1.0	33.54	26.99	.97349	107	48.70487	.07838
					125	2.4	34.42	27.47	.97272	64	121.68775	.14263
					250	3.2	34.73	27.66	.97198	46	243.23150	.21151
					450	3.2	34.80	27.72	.97104	42	437.53350	.30001
					750	3.1	34.87	27.78	.96966	37	728.63850	.41901
682	do	45 48	47 20	1,463	0	1.6	33.51	26.83	.97387	123	0	0
					25	0.1	33.57	26.97	.97363	110	24.34375	.02910
					50	0.9	33.86	27.15	.97334	92	48.68087	.05438
					125	2.1	34.47	27.56	.97263	55	121.65475	.10963
					250	3.0	34.70	27.66	.97195	43	243.19100	.17101
					450	3.1	34.78	27.71	.97105	43	437.49100	.25751
					750	3.6	34.85	27.73	.96972	43	728.60650	.38701
683	May 11	45 42	46 46	1,645	0	0.3	33.55	26.94	.97376	112	0	0
					25	0.6	33.70	27.04	.97356	103	24.34150	.02685
					50	1.6	33.98	27.20	.97329	87	48.67712	.05063
					125	1.7	34.49	27.61	.97257	49	121.64687	.13201
					250	3.0	34.81	27.75	.97189	37	243.17562	.15564
					450	3.2	34.90	27.78	.97098	36	437.46262	.22914
					750	3.4	34.91	27.79	.96966	37	728.55863	.33914

[1] Interpolated. [2] Exterpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude		Longitude		a depth of water	a_1 depth	a=Meters			a_1=Pressure in decibars			
								Temperature	Salinity 0/00	δ_t	V	V−V₁	E	E−E₁
		°	′	°	′			°C.						
684	May 11	45	18	46	45	2,743	0	4.2	33.71	26.76	0.97393	129	0	0
							25	3.4	33.76	26.87	.97372	119	24.34562	.03098
							50	3.7	33.81	26.89	.97358	116	48.68687	.06038
							125	3.8	34.41	27.35	.97283	75	121.67725	.13213
							250	3.9	34.71	27.58	.97206	54	243.23287	.21289
							450	3.6	34.89	27.75	.97102	40	437.54087	.30739
							750	3.4	34.90	27.78	.96967	38	728.64437	.42489
685	do	44	52	46	43	3,657	0	9.4	34.85	26.95	.97375	111	0	0
							25	9.6	34.80	26.88	.97371	118	24.34325	.02860
							50	9.5	34.74	26.85	.97373	131	48.68625	.05975
							125	9.2	34.83	26.96	.97321	113	121.69650	.15138
							250	4.9	34.46	27.25	.97238	86	243.29588	.27589
							450	4.4	34.80	27.58	.97118	56	437.65188	.41839
							750	4.2	34.94	27.72	.96974	45	728.78988	.57039
686	do	44	28	46	43	3,725	0	13.6	35.80	26.90	.97380	116	0	0
							25	13.7	35.78	26.87	.97372	119	24.34400	.03123
							50	13.8	35.76	26.83	.97365	123	48.68613	.06151
							125	13.2	35.77	26.97	.97320	112	121.69451	.14939
							250	10.8	35.41	27.15	.97251	99	243.30451	.28452
							450	5.8	35.03	27.62	.97116	54	437.69651	.46302
							750	5.0	34.98	27.68	.96980	51	728.87201	.65252
687	do	44	35	47	17	3,650	0	14.0	35.72	26.75	.97394	130	0	0
							25	14.0	35.86	26.86	.97373	120	24.34588	.03123
							50	14.1	35.86	26.84	.97364	122	48.68801	.06151
							125	13.5	35.87	26.98	.97320	112	121.69451	.14939
							250	10.9	35.38	27.10	.97256	104	243.30451	.28452
							450	5.3	34.67	27.40	.97136	74	437.69651	.46302
							750	5.0	34.96	27.66	.96981	52	728.87201	.65252
688	May 12	44	40	47	50	3,475	0	9.0	34.54	26.76	.97394	130	0	0
							25	9.1	34.56	26.77	.97382	129	24.34700	.03235
							50	9.2	[1] 34.60	26.79	.97369	127	48.69098	.06448
							125	[1] 9.1	34.68	26.87	.97329	1[illegible]1	121.70263	.15751
							250	[1] 7.5	34.61	27.06	.97258	106	243.31951	.29952
							450	5.1	34.63	27.36	.97140	78	437.71751	.48482
							750	4.8	34.95	27.67	.96981	52	728.89901	.67952
689	do	44	42	48	08	2,652	0	8.3	34.53	26.88	.97382	118	0	0
							25	8.2	34.53	26.89	.97370	117	24.34400	.02935
							50	8.1	34.52	26.90	.97358	116	48.68500	.05850
							125	6.2	[1] 34.31	27.00	.97316	108	121.68775	.14263
							250	5.8	34.57	27.25	.97238	86	243.28400	.26401
							450	4.9	34.89	27.60	.97117	55	437.63900	.40551
							750	4.0	34.92	27.74	.96972	43	728.77250	.55301
690	do	44	46	48	24	2,377	0	3.6	33.44	26.60	.97409	145	0	0
							25	3.6	33.60	26.73	.97385	132	24.34925	.03460
							50	3.5	33.96	27.03	.97345	103	48.69050	.06400
							125	3.3	34.33	27.32	.97286	78	121.67713	.13201
							250	3.2	34.81	27.70	.97194	42	243.22713	.20714
							450	3.0	34.93	27.83	.97093	31	437.51413	.28064
							750	2.7	34.91	27.85	.96959	30	728.59213	.37264
691	do	44	49	48	37	320	0	3.0	33.47	26.68	.97401	137	0	0
							25	3.0	33.65	26.82	.97377	124	24.34725	.03260
							50	2.9	33.97	27.05	.97344	102	48.68738	.06088
							125	4.0	[1] 34.42	27.34	.97284	76	121.67288	.12776
							250	4.3	34.74	27.55	.97209	57	243.2[illegible]101	.21102
							450	4.0	[1] 34.84	27.67	.97110	48	437.55001	.31652
							750	3.5	34.90	27.75	.96970	41	728.67001	.45052
692	do	44	52	48	51	201	0	0.6	32.90	26.41	.97427	163	0	0
							25	0.4	32.92	26.43	.97414	1[illegible]1	24.35513	.04048
							50	−1.6	33.30	26.82	.97[illegible]64	122	48.68[illegible]12	.07588
							125	0.7	33.70	27.03	.97313	105	97.35512	.16114
							200	1.8	33.90	27.12	.97271	97	146.00487	.23677
							240	2.4	34.16	27.27	.97239	84	194.63987	.31557
							250	------	-------	27.28	.97234	82	243.26262	.32092
693	do	43	53	49	09	238	0	8.4	34.50	26.84	.97386	122	0	0
							25	8.2	34.50	26.87	.97372	119	24.34475	.03010
							50	7.4	34.38	26.89	.97359	117	48.68612	.05963
							100	5.6	34.42	27.11	.97317	98	97.35512	.11338
							150	5.4	34.47	27.23	.97282	85	146.00487	.15914
							200	5.2	34.50	27.27	.97258	84	194.63987	.20136
							250	------	-------	27.31	.97233	81	243.26262	.24264

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	*a* depth of water	a_1 depth	*a*=Meters: Temperature	*a*=Meters: Salinity 0/00	*a*=Meters: δ_t	a_1=Pressure in decibars: V	a_1=Pressure in decibars: V−V_1	a_1=Pressure in decibars: E	a_1=Pressure in decibars: E−E_1
		° ′	° ′			°*C.*						
694	May 12	43 51	48 55	347	0	4.3	33.23	26.37	0.97431	167	0	0
					25	7.8	34.39	26.83	.97376	123	24.35087	.03623
					50	7.4	34.38	26.89	.97359	117	48.69275	.06625
					125	6.0	[1]34.33	27.04	.97313	105	121.69475	.14963
					250	5.6	[1]34.53	27.25	.97238	86	243.28912	.26914
					450	5.3	34.61	27.35	.97141	79	437.66812	.43464
					750	5.0	34.94	27.64	.96983	54	728.85412	.63464
695	May 13	43 49	48 42	2,524	0	11.0	35.20	26.95	.97375	111	0	0
					25	10.2	35.21	27.10	.97351	98	24.34075	.02610
					50	10.0	35.24	27.15	.97335	93	48.67650	.05000
					125	8.4	35.01	27.22	.97296	88	121.66312	.11801
					250	6.2	34.74	27.33	.97231	79	243.26750	.24751
					450	4.1	[1]34.63	27.50	.97126	64	437.62450	.39101
					750	3.9	34.92	27.75	.96971	42	728.77000	.55051
696	do	43 48	48 22	2,926	0	10.2	34.83	26.80	.97390	126	0	0
					25	10.4	34.87	26.80	.97379	126	24.34612	.03148
					50	10.6	35.05	26.90	.97358	106	48.68815	.06165
					125	6.6	34.55	27.11	.97307	99	121.68752	.14241
					250	4.9	34.64	27.40	.97224	72	243.26940	.24941
					450	4.2	34.83	27.62	.97114	52	437.60740	.37391
					750	4.1	34.95	27.75	.96971	42	728.73490	.51541
697	do	43 45	48 00	3,651	0	6.0	35.50	26.39	.97429	165	0	0
					25	5.8	33.72	26.58	.97400	147	24.35362	.03898
					50	4.7	33.96	26.89	.97358	116	48.69837	.07188
					125	4.0	34.62	27.45	.97273	65	121.68500	.13988
					250	4.5	34.91	27.66	.97198	46	243.22937	.20939
					450	4.4	34.98	27.73	.97104	42	437.53137	.29789
					750	4.0	34.97	27.78	.96968	39	728.63937	.41989
698	do	43 42	47 37	3,654	0	8.5	34.16	26.55	.97413	149	0	0
					25	9.9	34.71	26.76	.97383	130	24.34950	.03485
					50	8.9	[1]34.60	26.84	.97364	122	48.69287	.06638
					125	8.0	[1]34.59	26.97	.97320	112	121.69937	.15426
					250	7.6	34.72	27.13	.97251	99	243.30625	.28626
					450	3.3	34.54	27.50	.97125	63	437.68225	.44876
					750	4.8	34.93	27.65	.96980	51	728.83975	.62026
699	do	43 10	47 50	3,292	0	3.8	33.66	26.76	.97394	130	0	0
					25	3.6	33.64	26.76	.97383	130	24.34712	.03248
					50	2.8	[1]33.70	26.87	.97360	118	48.69000	.06350
					125	2.4	34.21	27.34	.97284	76	121.68150	.13638
					250	[1]3.4	34.66	27.59	.97204	52	243.36150	.34151
					450	4.0	34.92	27.74	.97103	41	437.66850	.43501
					750	3.8	[1]34.93	27.77	.96968	39	728.77500	.55551
700	May 14	42 15	48 44	3,152	0	6.4	[1]33.85	26.62	.97407	143	0	0
					25	6.2	33.85	26.64	.97394	141	24.35013	.03548
					50	5.0	33.88	26.82	.97365	123	48.69500	.06850
					125	4.7	34.36	27.22	.97295	87	121.69250	.14738
					250	4.3	34.78	27.58	.97206	54	243.25562	.23564
					450	3.8	34.75	27.62	.97114	52	437.57562	.34214
					750	3.6	34.96	27.80	.96965	36	728.694125	.47464
701	do	42 26	48.59	3,949	0	4.2	33.54	26.63	.97406	142	0	0
					25	2.8	33.51	26.73	.97385	132	24.34887	.03423
					50	2.0	33.61	26.88	.97359	117	48.69187	.06538
					125	4.1	34.42	27.30	.97288	80	121.68450	.13938
					250	[1]4.0	34.61	27.48	.97216	64	243.24950	.22951
					450	4.1	34.70	27.56	.97120	58	437.58550	.35201
					750	3.8	34.94	27.78	.96968	39	728.71750	.49801
702	do	42 34	49 08	2,560	0	6.6	33.92	26.64	.97405	141	0	0
					25	8.2	34.48	26.87	.97371	119	24.34713	.03248
					50	8.7	34.67	26.92	.97356	114	48.68812	.06163
					125	7.9	34.86	27.20	.97298	90	121.68337	.13826
					250	[1]6.2	[1]34.88	27.43	.97221	69	243.25775	.23776
					450	5.3	34.90	27.58	.97119	57	437.59775	.36426
					750	4.2	34.96	27.75	.96971	42	728.73275	.51326
703	do	42 42	49 18	2,359	0	6.8	33.78	26.52	.97416	152	0	0
					25	5.8	33.93	26.74	.97384	131	24.35000	.03535
					50	3.9	34.01	27.03	.97345	103	48.69112	.06463
					125	3.6	34.08	27.15	.97302	94	121.68375	.13863
					250	[1]4.4	[1]34.68	27.50	.97214	62	243.25625	.23626
					450	4.4	34.85	27.64	.97112	50	437.58225	.34876
					750	4.0	34.94	27.77	.96969	40	728.70375	.48426
704	do	42 49	49 28	1,832	0	6.5	33.91	26.65	.97404	140	0	0
					25	6.2	33.93	26.70	.97388	135	24.35000	.03535
					50	5.2	34.00	26.88	.97359	117	48.69337	.06687
					125	5.8	34.53	27.23	.97295	87	121.68862	.14350
					250	5.5	34.86	27.52	.97213	61	243.25612	.23613
					450	4.6	[1]34 88	27.65	.97112	50	437.58112	.34763
					750	4.2	34.94	27.74	.96972	43	728.70112	.48763

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	a=Meters: δ_t	a1=Pressure in decibars: V	a1=Pressure in decibars: V–V1	a1=Pressure in decibars: E	a1=Pressure in decibars: E–E
		° ′	° ′			°C.						
705	May 14	42 56	49 37	640	0	2.0	33.32	26.65	0.97404	140	0	0
					25	0.4	33.34	26.79	.97380	127	24.34800	.03335
					50	2.9	33.52	[1]26.90	.97357	115	48.69012	.06362
					125	5.9	34.51	27.20	.97298	90	121.68574	.14062
					250	5.3	34.68	27.40	.97224	72	243.26199	.24200
					450	4.6	[1]34.85	27.62	.97115	53	437.60099	.36750
					750	4.0	34.91	27.73	.96973	44	728.73299	.51350
706	do	43 03	49 47	160	0	3.1	33.36	26.58	.97411	147	0	0
					40	3.4	33.84	26.94	.97357	111	38.95360	.05150
					80	4.5	34.19	27.11	.97326	98	77.89020	.09320
					120	4.0	34.25	27.13	.97306	96	116.81660	.13215
					125	4.0	------	27.15	.97302	94	121.68180	.13668
					160	3.8	34.31	27.28	.97274	82	155.73260	.16831
707	May 15	42 29	49 56	2,743	0	5.2	33.12	26.18	.97449	185	0	0
					25	2.4	33.33	26.62	.97396	143	24.35562	.04097
					50	2.2	33.72	26.95	.97352	110	48.69912	.07262
					125	3.4	[1]34.13	27.17	.97300	92	121.69362	.14850
					250	5.4	34.70	27.40	.97223	71	243.27050	.25051
					450	4.2	34.78	27.61	.97115	53	437.60850	.37501
					750	4.0	34.88	27.73	.96973	44	728.74050	.52101
708	do	42 15	50 04	2,926	0	4.4	33.60	26.65	.97404	140	0	0
					25	4.2	33.64	26.70	.97388	135	24.34900	.03435
					50	5.0	33.86	26.79	.97368	126	48.69400	.06750
					125	5.3	34.57	27.32	.97296	94	121.69300	.14788
					250	5.6	34.94	27.57	.97208	56	243.25800	.23801
					450	4.4	34.90	27.68	.97109	47	437.57500	.34151
					750	4.0	34.99	27.79	.96967	38	728.68900	.46951
709	do	42 00	50 10	3,712	0	7.7	33.41	26.09	.97457	193	0	0
					25	7.4	34.31	26.83	.97376	123	24.35412	.03947
					50	10.3	34.99	26.91	.97357	115	48.69574	.06924
					125	6.7	34.59	27.15	.97303	95	121.69324	.14812
					250	5.2	34.57	27.33	.97231	79	243.27636	.25637
					450	4.6	34.88	27.65	.97112	50	437.61936	.38587
					750	4.3	35.05	27.80	.96967	38	728.73786	.51837
710	do	42 01	50 40	3,719	0	6.6	33.41	26.25	.97442	178	0	0
					25	6.4	33.51	26.35	.97421	168	24.35787	.03422
					50	4.7	33.86	26.82	.97366	124	48.70624	.07974
					125	3.3	34.22	27.25	.97292	84	121.70299	.15787
					250	3.7	34.61	27.52	.97212	60	243.26799	.24800
					450	3.9	34.78	27.73	.97104	42	437.58399	.35050
					750	4.2	34.96	27.75	.96971	42	728.69649	.47700
711	do	42 02	51 07	3,840	0	6.6	32.90	25.84	.97481	127	0	0
					25	3.8	33.32	26.49	.97408	155	24.36112	.04647
					50	3.6	33.85	26.93	.97354	112	48.70637	.07987
					125	7.0	34.74	27.23	.97295	87	121.69974	.15462
					250	5.4	34.78	27.47	.97218	66	243.27037	.25038
					450	4.2	34.74	27.58	.97118	56	437.60637	.37288
					750	4.0	34.98	27.78	.96968	39	728.73537	.51588
712	do	42 24	51 10	2,404	0	8.8	33.49	25.99	.97467	203	0	0
					25	8.2	33.85	26.36	.97421	168	24.36100	.04635
					50	10.6	34.96	26.83	.97365	123	48.71025	.08375
					125	11.6	35.32	26.93	.97324	116	121.71862	.17350
					250	9.0	35.13	27.23	.97262	110	243.32237	.30238
					450	5.0	34.69	27.45	.97131	69	437.69537	.46188
					750	4.2	34.88	27.68	.96978	40	728.85887	.63938
713	May 16	42 21	51 44	3,349	0	9.0	33.71	26.12	.97454	190	0	0
					25	10.8	34.18	26.57	.97401	148	24.35687	.04222
					50	11.8	35.24	26.83	.97305	123	48.70262	.07612
					125	11.7	35.31	26.90	.97327	119	121.71212	.16700
					250	9.4	34.96	27.03	.97261	109	243.32962	.30963
					450	5.0	34.54	27.33	.97143	81	437.73362	.50013
					750	4.3	34.94	27.72	.96975	46	728.91062	.69113
714	do	42 44	51 55	2,743	0	8.4	33.22	25.84	.97481	217	0	0
					25	7.0	33.66	26.25	.97431	178	24.36400	.04935
					50	9.0	34.23	26.53	.97393	151	48.71700	.09050
					125	10.0	35.10	27.05	.97312	104	121.73137	.18625
					250	[1]7.4	34.90	27.33	.97232	80	243.32137	.30138
					450	5.1	34.81	27.53	.97124	62	437.67737	.44388
					750	4.3	34.94	27.72	.96975	46	728.82587	.60638
715	do	42 59	51 46	2,194	0	6.8	32.88	25.80	.97485	221	0	0
					25	6.2	33.26	26.17	.97439	186	24.36550	.05085
					50	10.0	34.85	26.85	.97363	121	48.71575	.08925
					125	5.8	34.32	27.06	.97311	103	121.71850	.17338
					250	7.2	34.85	27.28	.97236	84	243.31047	.29048
					450	4.8	34.79	27.55	.97122	60	437.66387	.43038
					750	4.0	34.88	27.71	.96975	46	728.81387	.59438

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude		Longitude		*a* depth of water	*a*₁ depth	*a* = Meters			a_1 = Pressure in decibars			
								Temperature	Salinity 0/00	δ_t	V	V–V₁	E	E–E₁
		°	′	°	′			°*C.*						
716	May 16	43	06	51	35	768	0	6.3	32.72	25.74	.97490	226	0	0
							25	5.0	33.30	26.35	.97421	168	24.36387	.04922
							50	9.2	34.74	26.90	.97358	116	48.71124	.08474
							125	7.1	34.57	27.03	.97314	106	121.71324	.16812
							250	4.7	34.52	27.35	.97229	77	243.30261	.28262
							450	4.0	34.77	27.62	.97114	52	437.64561	.41212
							750	3.8	34.87	27.73	.96973	44	728.77611	.55662
717	do	43	15	51	24	549	0	5.8	32.59	25.70	.97494	230	0	0
							60	3.4	33.19	26.42	.97399	162	58.46790	.11745
							120	7.6	[1] 34.36	26.86	.97332	122	116.88720	.20275
							180	7.2	34.68	27.15	.97279	98	175.27050	.26911
							240	5.7	34.75	27.41	.97227	71	233.62230	.31861
							250	------	-------	27.42	.96222	70	243.34475	.32476
718	do	43	08	50	48	129	0	4.7	32.86	26.03	.97463	199	0	0
							25	3.6	33.02	26.27	.97429	176	24.36150	.04685
							50	[1] 1.8	33.24	26.60	.97386	144	48.71337	.08687
							75	0.8	33.38	26.78	.97358	127	73.05637	.12083
							100	3.4	33.96	27.03	.97324	105	97.39162	.14987
							125	------	-------	[2] 27.13	.97304	49	121.72012	.17500
719	do	42	58	50	58	1,079	0	5.2	32.61	25.78	.97487	223	0	0
							25	5.0	32.80	25.95	.97459	206	24.36825	.05360
							50	2.2	33.12	26.47	.97398	156	48.72537	.09887
							125	5.9	34.62	27.29	.97290	82	121.73337	.18825
							250	5.2	34.73	27.46	.97219	67	243.30149	.28150
							450	4.2	34.81	27.63	.97113	51	437.63349	.40000
							750	3.7	34.85	27.72	.96973	44	728.76249	.54300
720	do	42	45	51	11	1,280	0	5.2	32.36	25.59	.97505	241	0	0
							25	5.0	32.44	25.68	.97485	232	24.37375	.05901
							50	3.0	32.45	25.88	.97454	212	48.74112	.11462
							125	5.4	34.32	27.11	.97306	98	121.77612	.23100
							250	5.0	34.52	27.32	.97232	80	243.36237	.34238
							450	4.1	34.79	27.63	.97113	51	437.70737	.47388
							750	3.9	34.79	27.66	.96980	51	728.84687	.62738
721	May 17	42	40	50	40	2,103	0	5.4	32.42	25.61	.97503	239	0	0
							25	3.9	32.79	26.06	.97449	196	24.36900	.05435
							50	1.4	33.21	26.60	.97386	144	48.72337	.09687
							125	6.2	34.50	27.15	.97303	95	121.73174	.18662
							250	5.0	34.67	27.43	.97221	69	243.30924	.28925
							450	4.2	34.86	27.67	.97110	48	437.64024	.40675
							750	3.9	34.90	27.73	.96973	44	728.76474	.54525
722	do	42	53	50	14	367	0	4.2	33.40	26.51	.97417	153	0	0
							50	4.0	33.99	27.00	.97348	106	48.69125	.06475
							100	5.0	34.28	27.12	.97312	93	97.35625	.11450
							150	6.3	34.56	27.18	.97288	91	146.00625	.16051
							200	5.6	34.56	27.27	.97259	85	194.64300	.20451
							250	------	-------	[2] 27.30	.97234	82	243.26625	.24626
723	do	42	45	49	53	2,081	0	6.2	33.68	26.50	.97418	154	0	0
							25	5.1	33.84	26.76	.97383	141	24.35012	.03547
							50	4.8	34.29	27.16	.97333	91	48.68962	.06312
							125	5.6	34.55	27.27	.97242	84	121.67399	.12887
							250	5.3	34.83	27.52	.97213	61	243.26461	.24462
							450	4.4	34.93	27.70	.97107	45	437.58461	.35112
							750	4.0	34.90	27.73	.96973	44	728.70461	.48512
724	do	42	26	50	20	2,834	0	5.8	32.52	25.63	.97501	237	0	0
							25	3.3	32.76	26.08	.97447	194	24.36850	.05385
							50	2.2	33.14	26.48	.97397	155	48.72400	.09750
							125	8.2	34.89	27.16	.97302	94	121.73615	.19103
							250	5.5	34.75	27.43	.97221	69	243.31302	.29303
							450	4.2	34.86	27.67	.97110	48	437.64402	.41053
							750	3.7	34.84	27.71	.96974	45	728.77002	.55053
725	do	42	20	50	48	2,871	0	7.6	32.98	25.77	.97488	224	0	0
							25	6.8	33.34	26.16	.97440	187	24.36600	.05135
							50	10.8	35.07	26.88	.97360	118	48.71600	.08950
							125	7.8	34.67	27.06	.97312	104	121.71800	.17288
							250	5.6	34.71	27.39	.97225	73	243.30362	.28363
							450	3.8	34.75	27.62	.97114	52	437.64262	.40913
							750	3.7	34.86	27.72	.96973	44	728.77312	.55363
726	do	42	10	50	29	3,292	0	8.4	33.41	25.98	.97468	224	0	0
							25	5.2	33.60	26.56	.97402	149	24.35875	.04410
							50	3.8	33.70	26.80	.97367	125	48.70487	.07837
							125	5.0	34.34	27.17	.97300	92	121.70499	.15987
							250	6.0	34.57	27.23	.97240	88	243.29249	.27250
							450	4.6	34.84	27.61	.97116	54	437.64849	.41500
							750	4.0	34.91	27.73	.96973	44	728.78199	.56250

[1] Interpolated.
[2] Exinterpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: $V-V_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: $E-E_1$
		° ′	° ′			°C.						
727	May 19	41 47	49 30	3,657	0	11.2	33.64	25.70	0.97494	230	0	0
					25	7.9	33.85	26.41	.97416	163	24.36375	.04910
					50	12.6	35.26	26.69	.97378	136	48.71300	.08650
					125	11.6	35.31	26.92	.97325	117	121.72662	.18150
					250	8.6	34.90	27.18	.97246	94	243.33349	.31350
					450	5.2	34.80	27.47	.97131	69	437.71049	.47700
					750	4.4	34.96	27.73	.96974	45	728.86799	.64850
728	do	42 15	49 20	3,152	0	8.6	33.79	26.25	.97442	178	0	0
					25	5.4	33.76	26.67	.97391	138	24.35412	.03947
					50	4.6	33.94	26.90	.97357	115	48.69762	.07112
					125	4.9	34.55	27.35	.97283	75	121.68762	.14250
					250	4.7	34.73	27.52	.97212	61	243.24762	.32763
					450	4.4	34.91	27.68	.97109	47	437.56962	.33613
					750	4.0	34.94	27.76	.96970	41	728.68812	.46863
729	do	42 44	48 44	2,853	0	4.2	33.32	26.44	.97424	160	0	0
					25	1.2	33.36	26.73	.97385	132	24.35112	.03647
					50	1.6	33.70	26.98	.97350	108	48.69299	.06649
					125	5.0	34.41	27.22	.97295	87	121.68486	.13974
					250	5.2	[1] 34.64	27.38	.97226	74	243.26048	.24049
					450	5.0	34.80	27.54	.97123	61	437.60948	.37599
					750	4.6	34.84	27.59	.96987	58	728.77448	.38999
730	do	42 55	48 22	3,291	0	3.6	33.11	26.34	.97433	169	0	0
					25	2.3	33.86	27.05	.97353	102	24.34850	.03385
					50	1.0	33.80	27.10	.97339	97	48.68625	.05975
					125	7.0	34.68	27.18	.97299	91	121.67550	.13038
					250	5.4	34.74	27.44	.97220	68	243.24988	.22989
					450	4.9	34.96	27.65	.97112	50	437.58188	.34838
					750	3.6	34.88	27.75	.96970	41	728.70488	.48539
731	May 20	43 04	48 39	3,265	0	3.2	33.42	26.62	.97407	143	0	0
					25	3.2	[1] 33.55	26.79	.97380	127	24.34713	.03248
					50	4.0	33.89	26.92	.97355	113	48.68901	.06251
					125	5.7	34.50	27.22	.97295	87	121.68276	.13764
					250	4.6	[1] 34.60	27.42	.97222	70	243.25589	.23590
					450	3.8	34.80	27.66	.97111	49	437.58889	.35540
					750	3.5	34.91	27.78	.96967	38	728.70589	.48640
732	do	43 12	48 55	2,194	0	6.2	33.50	26.36	.97432	168	0	0
					25	5.6	33.84	26.71	.97387	134	24.35238	.03773
					50	5.9	34.08	26.86	.97362	120	48.69601	.06951
					125	5.0	34.38	27.20	.97298	90	121.69351	.14839
					250	4.0	34.58	27.50	.97214	62	243.26351	.24352
					450	3.6	34.87	27.73	.97104	42	437.58151	.34802
					750	3.4	34.84	27.74	.96970	41	728.69251	.47302
733	do	43 18	49 06	1,326	0	8.0	34.10	26.73	.97396	132	0	0
					25	4.6	33.77	26.76	.97383	130	24.34738	.03273
					50	4.4	33.93	26.91	.97356	114	48.66476	.03826
					125	4.2	34.45	27.35	.97283	75	121.65439	.10927
					250	4.0	34.68	27.50	.97215	63	243.21564	.19565
					450	3.8	34.84	27.70	.97107	45	437.53764	.30415
					750	3.6	34.88	27.75	.96970	41	728.64864	.42915
734	do	43 24	49 17	420	0	7.2	33.74	26.42	.97426	162	0	0
					70	3.6	33.95	27.01	.97340	107	68.16810	.09415
					140	3.0	34.25	27.30	.97281	80	136.28545	------
					210	4.6	------	27.45	.97237	67	204.36675	------
					280	3.8	34.65	27.55	.97195	57	272.41759	------
					350	3.5	34.73	27.63	.97157	50	340.44115	.29191
					420	3.4	34.76	27.67	.97122	42	408.43880	.33966
					450	------	------	27.69	.97107	45	437.57315	------
735	do	43 33	49 36	57	0	4.0	33.10	26.30	.97437	173	0	0
					10	3.8	33.22	26.41	.97422	162	9.74295	.01675
					25	2.2	33.13	26.46	.97411	158	24.35542	.04077
					40	0.7	33.17	26.61	.97389	143	38.96542	.06332
					50	[1] 2.5	------	26.62	.97384	142	48.70407	.07757
					55	------	------	26.63	.97381	141	53.57319	.08465
736	do	43 35	49 48	44	0	3.8	33.08	26.30	.96437	173	0	0
					10	3.8	33.07	26.29	.97433	173	9.7435	.01730
					20	3.4	33.11	26.35	.97423	168	19.4863	.03435
					30	2.2	33.09	26.44	.97410	159	29.2279	.05065
					40	2.1	33.05	26.43	.97406	160	38.9687	.06660
737	do	43 46	50 00	59	0	5.2	33.10	26.17	.97450	186	0	0
					14	4.8	33.07	26.18	.97442	184	13.64244	------
					28	2.1	33.11	26.47	.97408	156	27.28194	------
					42	1.3	33.24	26.64	.97385	140	40.91745	------
					56	6.2	33.21	26.62	.97382	142	54.55114	------

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	a=Meters: δ_t	a_1=Pressure in decibars: V	a_1=Pressure in decibars: V−V_1	a_1=Pressure in decibars: E	a_1=Pressure in decibars: E−E_1
		° ′	° ′			°C.						
738	May 29	45 33	48 09	64	0	2.6	33.36	26.63	0.97406	142	0	0
					25	2.9	33.74	26.91	.97368	115	24.34675	.03210
					50	0.6	[1]33.75	27.08	.97341	99	48.68538	.05888
					125	1.6	34.26	27.42	.97276	68	121.66675	.12163
					250	2.6	[1]34.61	27.63	.97200	48	243.21425	.19426
					450	3.1	34.81	27.75	.97101	39	347.51525	.28176
					750	3.2	34.89	27.79	.96965	36	728.61425	.39476
739	do	45 33	48 24		0	1.6	33.17	26.55	.97413	151	0	0
					25	1.0	33.46	26.82	.97377	124	24.34875	.03410
					50	1.4	33.74	27.02	.97346	104	48.68913	.06263
					125	0.6	[1]34.64	27.35	.97282	74	121.67463	.12951
					250	2.3	[1]34.55	27.61	.97202	50	243.22713	.20714
					450	3.2	[1]34.81	27.74	.97102	40	437.53113	.29764
					750	3.4	[1]34.92	27.80	.96965	36	728.63163	.41214
740	do	45 33	48 39	625	0	1.8	32.91	26.33	.97434	170	0	0
					25	−1.2	32.92	26.38	.97419	166	24.35663	.04198
					50	−1.2	33.54	26.99	.97349	107	48.70263	.07613
					125	−1.0	33.69	27.11	.97305	97	121.69788	.15276
					250	−0.6	33.85	27.22	.97239	87	243.28788	.26789
					450	2.4	34.59	27.53	.97112	50	437.63888	.40539
741	do	45 33	48 54	84	0	2.8	32.88	26.23	.97444	180	0	0
					20	2.4	32.82	26.23	.97435	180	19.48790	.03595
					40	0.2	32.87	26.39	.97410	164	38.97240	.07030
					50	------	-------	[1]26.47	.97398	156	48.71280	.08630
					60	−1.2	33.12	26.65	.97377	140	58.45155	.10110
					80	−1.5	33.18	26.71	.97362	134	77.92545	.12845
					125	------	-------	[1]27.11	.97305	97	121.72553	.18041
724	do	45 33	49 10	57	0	2.8	32.99	26.32	.97435	171	0	0
					16	2.4	32.97	26.35	.97455	168	15.58880	-------
					32	2.0	33.10	26.47	.97407	157	31.17536	-------
					48	−1.6	33.33	26.83	.97365	122	46.75712	-------
					50	------	-------	[1]26.84	.97363	121	48.70440	.07790
					64	−1.4	33.37	26.87	.97354	119	62.33459	-------
743	do	45 14	49 28	63	0	3.0	33.06	26.35	.97432	168	0	0
					15	2.8	33.01	26.33	.97427	170	14.61442	.02528
					30	−0.6	33.17	26.67	.97388	137	29.22555	.04830
					45	−0.8	33.43	26.89	.97360	116	43.83165	.06730
					50	------	-------	[1]26.90	.97357	115	48.69957	.07307
					60	−1.0	33.50	26.95	.97348	111	58.43482	.08437
744	do	45 10	49 15	54	0	2.6	32.87	26.22	.97445	181	0	0
					16	2.6	33.01	26.40	.97421	164	15.58928	-------
					32	−0.8	33.12	26.64	.97390	140	31.17416	-------
					48	−1.4	33.33	26.83	.97365	122	46.74756	-------
					50	------	-------	26.84	.97363	121	48.70184	.07534
					64	−1.6	33.43	26.92	.97350	115	62.33175	-------
745	May 30	45 06	49 00	201	0	2.8	32.79	26.16	.97451	187	0	0
					15	2.5	32.86	26.24	.97436	179	14.61652	.02738
					30	−1.0	33.10	26.63	.97392	141	29.22862	.05137
					45	−1.6	33.26	26.86	.97363	119	43.83525	.07090
					50	------	-------	26.86	.97361	119	48.70335	.07685
					60	−1.8	33.32	26.86	.97358	121	58.43930	.08885
746	do	45 02	48 47	210	0	2.4	31.41	26.69	.97400	136	0	0
					25	2.0	33.37	26.72	.97386	133	24.34825	.03360
					50	1.4	33.81	27.08	.97341	104	48.68912	.06262
					125	1.8	34.45	27.48	.97371	163	121.66862	.12350
					250	3.0	34.78	27.72	.97192	40	243.20799	.28800
					450	3.2	34.86	27.77	.97099	37	437.49899	.26550
					750	3.3	34.89	27.79	.96965	36	728.59499	.37550
747	do	44 58	48 34	732	0	3.2	33.28	26.51	.97417	153	0	0
					25	1.6	33.65	26.94	.97365	112	24.34775	.03310
					50	0.9	34.23	27.41	.97304	62	48.68137	.05487
					125	2.2	34.52	27.59	.97260	52	121.61699	.07187
					250	3.2	34.80	27.70	.97194	42	243.15074	.03075
					450	2.9	34.75	27.72	.97104	42	437.44874	.11525
					750	3.6	34.88	27.75	.96970	41	728.55974	.34025
748	do	44 55	48 18	2,011	0	3.8	32.26	25.65	.97499	235	0	0
					25	3.1	33.49	26.69	.97399	146	24.36100	.04635
					50	2.8	33.94	27.08	.97341	99	48.70225	.09575
					125	2.7	34.58	27.60	.97259	51	121.67725	.13213
					250	3.4	34.82	27.72	.97192	40	243.20912	.18913
					450	2.9	34.77	27.73	.97103	41	437.50412	.27063
					750	3.6	34.88	27.75	.96970	41	720.61362	.39413

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters			a_1=Pressure in decibars			
						Temperature	Salinity 0/00	δ_t	V	V-V₁	E	E-E₁
		° ′	° ′			° C.						
749	May 30	44 50	47 59	2,377	0	3.0	32.73	26.09	0.97457	193	0	0
					25	1.7	32.75	26.21	.97435	182	24.36510	.04685
					50	−1.0	33.30	26.79	.97368	126	48.71187	.08537
					125	0.6	33.90	27.20	.97296	88	121.71462	.16590
					250	4.0	34.66	27.53	.97211	59	243.28149	.26150
					450	4.4	34.86	27.65	.97111	49	437.60349	.37000
					750	4.2	34.95	27.75	.96971	42	728.72649	.50700
750	do	44 41	47 40	2,925	0	9.9	33.93	26.29	.97438	174	0	0
					25	9.6	33.95	26.22	.97434	181	24.35900	.04435
					50	9.2	34.29	26.55	.97391	149	48.71212	.08562
					125	6.6	34.58	27.16	.97302	94	121.72199	.17687
					250	5.1	34.74	27.48	.97217	65	243.29636	.27637
					450	4.0	34.82	27.66	.97110	48	437.62336	.38987
					750	4.4	34.96	27.73	.96974	45	728.74936	.52987
751	do	45 19	47 53	2,743	0	4.0	32.71	25.99	.97467	203	0	0
					25	6.0	33.73	26.58	.97400	149	24.5837	.04372
					50	3.8	33.89	26.95	.97352	110	48.70237	.07857
					125	3.4	34.38	27.37	.97281	73	121.68974	.14462
					250	4.6	34.80	27.58	.97207	55	243.24474	.22475
					450	4.5	34.82	27.61	.97116	54	437.56674	.33425
					750	4.4	34.88	27.67	.96980	51	728.71174	.49225
752	June 1	44 24	49 04	55	0	3.2	32.85	26.17				
					13	3.7	32.92	26.27				
					26	0.2	33.14	26.64				
					39	−0.4	33.23	26.72				
					50			26.73			48.70271	
					52	−0.5	33.25	26.73			50.65017	
753	do	44 23	48 48	1,316	0	2.8	33.06	26.37	.97431	167	0	0
					25	2.2	33.11	26.47	.97410	157	24.35512	.04047
					50	1.7	34.24	26.61	.97385	143	48.70449	.07799
					125	−0.3	34.76	27.14	.97302	94	121.71211	.16699
					250	2.2	34.53	27.60	.97203	51	243.27773	.25774
					450	3.0	[1]34.77	27.72	.97104	42	437.58473	.35124
					750	3.3	[1]34.87	27.76	.96966	37	728.68973	.47024
754	do	44 22	48 36	3,332	0	2.6	33.11	26.43	.97425	161	0	0
					25	2.4	33.37	26.66	.97392	139	24.35212	.03747
					50	1.2	33.61	26.93	.97354	112	48.69537	.06887
					125	0.8	34.32	27.54	.97264	56	121.67712	.13200
					250	2.6	34.70	27.70	.97194	42	243.21337	.19338
					450	3.1	34.83	27.76	.97100	38	437.50237	.27388
					750	3.3	34.86	27.78	.96966	37	728.60637	.38688
755	do	44 22	48 20	3,423	0	3.2	32.93	26.24	.97443	179	0	0
					25	2.7	33.19	26.49	.97408	155	24.35638	.04173
					50	1.6	33.50	26.82	.97365	123	48.70301	.07651
					125	1.0	34.09	27.34	.97284	76	121.69639	.15127
					250	2.5	34.50	27.55	.97208	56	243.25389	.23390
					450	4.6	[1]34.86	27.63	.97114	52	437.57589	.34240
					750	4.3	[1]34.91	27.70	.96977	48	728.71239	.49290
756	do	44 24	47 58	3,474	0	13.8	35.53	26.65	.97404	240	0	0
					25	14.0	35.54	26.62	.97396	143	24.35000	.03535
					50	14.4	35.84	26.77	.97371	120	48.69588	.06938
					125	11.2	35.22	26.80	.97336	128	121.71101	.16589
					250	7.8	34.93	27.22	.97242	90	243.32226	.30227
					450	5.4	34.87	27.54	.97123	61	437.68726	.45377
					750	4.4	34.81	27.61	.96984	65	728.84776	.62827
757	do	44 10	47 52	3,656	0	12.2	34.98	26.55	.97413	149	0	0
					25	12.0	35.00	26.61	.97397	144	24.35125	.03660
					50	13.2	35.55	26.80	.97368	126	48.69687	.07037
					125	13.4	35.99	27.09	.97310	102	121.70112	.15600
					250	11.3	35.73	27.29	.97238	86	243.29362	.27363
					450	6.7	34.95	27.44	.97134	72	437.66562	.43213
					750	5.9	35.07	27.64	.96989	55	728.84262	.62313
758	do	43 51	47 47	3,809	0	9.2	33.90	26.24	.97443	179	0	0
					25	12.6	35.44	26.42	.97415	162	24.35725	.04260
					50		35.83	26.63	.97384	142	48.70712	.08062
					125	14.6	35.96	26.81	.97336	128	121.72712	.18200
					250	8.5	34.75	27.02	.97262	110	243.35087	.33088
					450	6.5	34.94	27.41	.97137	75	437.74987	.51638
					750	5.0	34.87	27.59	.96988	59	728.93737	.71788
759	June 2	43 47	47 44	3,729	0	7.8	33.73	26.33	.97434	170	0	0
					25	8.6	34.13	26.52	.97405	152	24.35487	.04022
					50	13.8	35.63	26.73	.97374	132	48.70224	.07574
					125	15.0	36.05	26.80	.97337	129	121.71886	.17374
					250	10.9	35.09	26.88	.97276	124	243.35198	.33199
					450	6.0	34.63	27.28	.97149	87	437.77698	.54349
					750	5.0	34.64	27.41	.97005	76	728.00798	.78849

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a=Meters: Temperature	a=Meters: Salinity 0/00	δ_t	a_1=Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C.						
760	June 2	43 41	48 18	3,017	0	7.4	33.60	26.28	0.97439	175	0	0
					25	6.6	33.72	26.49	.97408	155	24.35587	.04122
					50	4.8	33.95	26.89	.97358	116	48.70162	.07512
					125	4.9	34.41	27.20	.97297	89	121.69724	.15212
					250	4.4	34.70	27.52	.97212	60	243.26536	.24537
					450	4.2	34.89	27.69	.97108	46	437.58536	.35187
					750	4.0	34.92	27.74	.96972	43	728.70536	.48587
761	do	43 36	48 42	2,005	0	2.6	32.77	26.15	.97451	187	0	0
					25	1.4	32.88	26.33	.97423	170	24.35925	.04460
					50	−0.8	33.29	26.78	.97369	127	48.70825	.08175
					125	−1.4	33.41	26.90	.97324	116	121.71812	.17300
					250	0.4	33.91	27.23	.97237	85	243.31999	.30000
					450	3.9	34.73	27.60	.97116	54	437.67299	.43950
					750	4.4	[1] 34.92	27.70	.96977	48	728.81249	.59300
762	do	43 37	48 56	1,463	0	3.2	32.80	26.13	.97453	189	0	0
					25	0.6	33.12	26.58	.97400	147	24.35662	.04197
					50	−1.4	33.29	26.79	.97368	126	48.70262	.07612
					125	−1.4	33.39	26.88	.97326	118	121.71287	.16775
					250	−0.2	33.83	27.20	.97240	88	243.31662	.29663
					450	[1] 3.8	[1] 34.68	27.57	.97119	57	437.67562	.44213
					750	[1] 4.0	[1] 34.89	27.72	.96974	45	728.81512	.59563
763	do	43 37	49 09	457	0	3.6	32.69	26.01	.97465	201	0	0
					25	1.8	32.79	32.79	.97432	179	24.36212	.04747
					50	−1.0	33.29	33.29	.97369	127	48.71224	.08574
					125	−1.2	33.46	33.46	.97321	113	121.72099	.17587
					250	2.0	34.17	34.17	.97225	73	243.31229	.29230
					450	3.0	34.72	34.72	.97107	45	437.64429	.41080
					750	3.4	[1] 34.87	[1] 34.87	.96971	42	728.76129	.54180
764	do	43 37	49 23	366	0	3.2	32.83	26.15	.97451	187	0	0
					25	2.5	33.89	26.26	.97430	177	24.36012	.04547
					50	−1.2	33.19	26.72	.97374	132	48.71062	.08412
					125	−1.3	33.41	26.89	.97325	117	121.72274	.17762
					250	0.6	33.76	27.10	.97251	99	243.33274	.31725
					450	3.4	34.38	27.37	.97137	75	437.72074	.48725
					750	3.5	34.77	27.68	.96977	48	728.89174	.67225
765	do	43 36	49 23	66	0	4.8	33.03	26.15	.97451		0	0
					15	4.2	32.95	26.16	.97443		14.61705	
					30	1.6	32.97	26.42	.97412		29.23117	
					45	−0.4	33.10	26.61	.97387		43.84109	
					50			26.63	.97383		48.71034	.08384
					60	0.0	33.22	26.69	.97373		58.44804	
766	June 3	43 56	48 54	1,097	0	3.2	32.82	26.15	.97451	187	0	0
					25	2.6	32.87	26.24	.97432	179	24.36037	.04572
					50	−0.6	33.13	26.65	.97381	139	48.71199	.08549
					125	−0.1	33.45	26.89	.97325	117	121.72674	.18162
					250	1.5	34.23	27.41	.97221	69	243.31799	.29800
					450	3.2	34.78	27.71	.97105	43	437.64399	.41050
					750	3.4	34.82	27.72	.96973	44	728.76099	.54050
767	do	43 59	48 30	3,294	0	4.0	32.87	26.12	.97454	190	0	0
					25	2.8	32.89	26.24	.97432	179	24.36075	.04610
					50	−1.3	33.21	26.73	.97373	131	48.71137	.08487
					125	−1.1	33.48	26.93	.97321	113	121.72152	.17640
					250	+1.6	34.24	27.41	.97221	69	243.31027	.29028
					450	3.9	34.80	27.66	.97111	49	437.64227	.40878
					750	4.0	34.91	27.73	.96973	44	728.76827	.54878
768	do	44 05	48 40	2,081	0	2.4	33.09	26.43	.97425	161	0	0
					25	1.8	33.11	26.50	.97407	154	24.35400	.03935
					50	1.6	33.50	26.83	.97374	132	48.71137	.08487
					125	0.8	33.86	27.17	.97299	91	121.68549	.14037
					250	2.0	34.43	27.53	.97210	58	243.25361	.23362
					450	3.1	34.66	27.61	.97114	52	437.57761	.34412
					750	3.9	34.69	27.65	.96980	51	728.71861	.49912
769	do	44 11	48 52	1,126	0	3.2	32.88	26.19	.97448	184	0	0
					25	2.2	32.95	26.34	.97422	169	24.35875	.04410
					50	2.0	33.39	26.71	.97375	133	48.70637	.07987
					125	1.1	33.94	27.21	.97295	87	121.70762	.16250
					250	2.6	34.44	27.49	.97214	62	243.27574	.25575
					450	3.2	34.62	27.59	.97116	54	437.60574	.37225
					750	3.4	34.70	27.64	.96980	51	728.74974	.53025
770	June 9	47 18	49 18	83	0	3.4	32.43	25.82	.97483	0	0	0
					20	3.2	32.45	25.86	.97470	215	19.49530	.04345
					40	2.8	32.84	26.19	.97429	183	38.98520	.08310
					60	−1.2	33.08	26.63	.97379	142	58.46600	.11555
					80	−1.4	33.22	26.75	.97358	130	77.93970	.14270
					90			[1] 26.80	.97350	126	87.67510	.15550

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	δ_t	a_1 = Pressure in decibars: V	V−V$_1$	E	E−E$_1$
		° ′	° ′			°C.						
771	June 10	47 24	49 00	98	0	3.4	32.49	25.87	0.97478	------	0	0
					18	3.2	32.52	25.91	.97466	------	17.54496	------
					36	0.8	32.78	26.30	.97421	------	35.08479	------
					54	0.6	[1]33.12	26.58	.97386	------	52.61742	------
					72	−1.4	33.14	26.68	.97362	------	70.14474	------
					90	−1.3	33.22	26.74	.97355	131	87.66927	.14967
					100	------	------	26.75	.97349	130	97.40447	.16272
772	do	47 31	48 43	155	0	3.4	32.65	26.00	.97466	202	0	0
					25	−1.6	33.18	26.73	.97385	132	24.35638	.04173
					50	−1.3	33.37	26.87	.97360	118	48.69950	.07300
					100	−1.0	33.46	26.92	.97333	114	97.37275	.13100
					150	0.0	33.81	27.17	.97287	90	146.02775	.18201
773	do	47 37	48 25	210	0	3.4	32.70	26.04	.97462	198	0	0
					25	−1.6	33.17	26.71	.97387	134	24.35613	.04148
					50	−1.4	33.41	26.89	.97358	116	48.69925	.07275
					100	−0.6	33.67	27.08	.97319	100	97.36850	.12675
					150	0.2	33.91	27.24	.97280	93	146.01825	.17251
					200	0.8	34.03	27.29	.97255	81	194.65200	.21351
774	do	47 44	48 06	292	0	4.0	33.11	26.31	.97436	172	0	0
					25	3.3	33.13	26.38	.97419	166	24.35687	.04222
					50	1.6	33.48	26.76	.97370	128	48.70549	.07899
					100	1.2	34.14	27.36	.97292	73	97.37099	.12924
					175	2.0	34.40	[1]27.51	.97245	59	170.32236	------
					200	------	------	27.53	.97232	58	194.63198	.14349
					250	------	------	[1]27.56	.97207	55	243.24173	.22174
					275	2.4	34.52	27.59	.97192	51	267.54160	------
775	do	47 51	47 47	383	0	3.6	32.73	26.04	.97462	198	0	0
					25	−0.8	33.01	26.55	.97402	149	24.35800	.04335
					75	−1.4	33.51	26.98	.97339	108	73.04325	.10771
					150	1.4	34.22	27.41	.97264	67	146.01937	.17363
					250	1.6	34.59	27.69	.97195	43	243.24887	.22888
					375	1.8	34.64	26.98	.97135	39	364.70512	------
776	do	48 03	47 32	909	0	4.6	33.72	26.72	.96397	133	0	0
					25	4.2	34.07	27.05	.97355	102	24.34400	.02935
					50	2.2	34.04	27.21	.97328	86	48.67937	.05287
					125	2.0	34.46	27.56	.97263	55	121.65099	.10587
					250	2.6	34.60	27.61	.97202	50	243.19161	.17162
					375	------	------	[1]27.66	.97141	45	364.65598	------
					450	2.8	34.73	27.70	.97106	44	437.49860	.26511
					750	3.3	34.83	27.73	.96972	43	728.61560	.39611
777	June 11	47 59	46 57	1,097	0	4.2	33.61	26.68	.97401	137	0	0
					25	3.0	34.10	27.18	.97343	90	24.34300	.02835
					50	2.1	34.29	27.42	.97308	66	48.67437	.04787
					125	2.4	34.54	27.59	.97260	52	121.63737	.09225
					250	3.0	34.76	27.71	.97195	43	243.16674	.14675
					450	3.1	34.83	27.75	.97101	39	437.46274	.22925
					750	3.2	34.87	27.77	.96967	38	728.56474	.34525
778	do	47 54	46 22	1,152	0	5.8	34.29	27.04	.97367	103	0	0
					25	5.0	34.39	27.21	.97340	87	24.33837	.02372
					50	[1]4.1	34.47	27.37	.97313	71	48.66999	.04349
					125	3.0	34.59	27.57	.97262	54	121.63561	.09049
					250	3.2	34.82	27.73	.97191	39	243.16873	.14874
					375	------	------	[1]27.73	.97135	39	364.62248	------
					450	3.4	34.85	27.74	.97103	41	437.46173	.22824
					750	[1]3.6	34.89	27.76	.96969	40	728.56973	.35024
779	do	47 49	45 50	380	0	6.0	34.17	26.92	.97372	114	0	0
					25	5.0	34.16	27.02	.97358	105	24.34200	.02735
					75	3.4	34.38	27.37	.97302	71	73.00700	.07146
					150	3.0	34.56	27.55	.97252	55	145.96475	.11901
					250	3.2	34.80	27.72	.97192	40	243.18675	.16676
					375	3.4	34.85	27.75	.97134	38	364.64050	------
780	do	47 30	46 08	769	0	5.5	[1]33.75	26.65	.97404	140	0	0
					25	5.2	33.98	26.86	.97373	120	24.34712	.03247
					50	[1]4.6	34.13	27.05	.97343	101	48.68662	.06012
					125	3.0	34.47	27.47	.97272	64	121.66724	.12212
					250	3.1	34.70	27.65	.97196	44	243.20974	.18975
					375	------	------	[1]27.67	.97142	46	364.67099	------
					450	3.4	34.79	27.69	.97107	45	437.51436	.28087
					750	3.3	34.85	27.75	.96970	41	728.62986	.41037
781	do	47 20	46 29	760	0	6.6	34.05	26.75	.97394	130	0	0
					25	6.0	34.08	26.85	.97374	121	24.34600	.03135
					50	4.8	34.28	27.15	.97334	92	48.68450	.05800
					125	3.2	34.63	27.58	.97261	53	121.65767	.11257
					250	3.2	34.78	27.70	.97194	42	243.19200	.17201
					450	3.4	34.86	27.75	.97101	39	437.48700	.25351
					750	3.3	34.85	27.75	.96970	41	728.59350	.37401

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: V−V$_1$	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: E−E$_1$
		° ′	° ′			°C.						
782	June 11	47 11	46 49	887	0	5.4	33.90	26.77	0.97393	129	0	0
					25	4.3	34.11	27.06	.97355	102	24.34350	.02885
					50	3.0	34.27	27.32	.97318	76	48.67762	.05112
					125	2.8	34.65	27.55	.97264	56	121.64487	.09975
					200	------	------	27.64	.97221	47	194.57674	.13825
					250	3.1	34.71	27.66	.97198	46	243.18149	.16150
					450	3.2	34.80	27.72	.97104	42	437.48349	.25000
					750	3.3	34.86	27.76	.96969	40	728.59299	.37350
783	do	47 05	47 16	262	0	4.0	33.28	26.44	.97424	160	0	0
					25	1.0	33.12	26.55	.97402	149	24.35325	.03860
					50	0.2	33.43	26.85	.97362	120	48.69875	.07225
					100	−0.4	33.73	27.12	.97315	96	97.36800	.12625
					150	1.4	34.16	27.36	.97269	72	146.01400	.16826
					200	2.4	34.49	27.57	.97228	54	194.63825	.19976
784	do	47 00	47 41	182	0	3.6	32.81	26.10	.97456	192	0	0
					25	[1] 3.2	33.01	26.29	.97427	174	24.36037	.04572
					50	[1] 1.8	[1] 33.04	26.44	.97401	159	48.71387	.08737
					75	−0.2	33.07	26.59	.97376	145	73.06099	.12545
					90	------	------	26.69	.97360	136	87.66619	.14659
					100	−1.2	33.22	26.74	.97350	131	97.40169	.15994
					125	−1.4	33.44	26.91	.97323	115	121.73581	.19069
					150	------	------	26.96	.97306	109	146.06443	.21869
					175	−1.0	33.55	27.00	.97292	83	170.38918	------
785	do	46 54	48 04	128	0	3.8	32.62	25.93	.97472	208	0	0
					30	1.2	32.90	26.36	.97417	166	29.23335	.05610
					60	−1.4	33.13	26.67	.97375	138	58.45215	.10170
					90	−1.0	33.43	26.90	.97340	116	87.65940	.13980
					120	−0.3	33.66	27.06	.97312	102	116.85720	------
					125	------	------	27.06	.97310	------	121.72275	------
786	June 12	46 49	48 26	96	0	4.4	32.49	25.77	.97488	224	0	0
					23	3.6	32.59	25.93	.97462	208	22.41925	------
					46	−0.6	32.88	26.44	.97403	159	44.82872	------
					69	−1.4	33.07	26.62	.97376	143	67.22830	------
					90	------	------	26.79	.97351	127	87.67463	.15503
					92	−1.2	33.30	26.80	.97349	126	89.62163	------
787	do	46 15	48 27	93	0	4.6	32.51	25.82	.97483	219	0	0
					23	4.0	32.62	25.91	.97464	210	22.41890	------
					46	2.0	32.71	26.16	.97430	186	44.83171	------
					69	1.3	33.19	26.72	.97366	133	67.23325	------
					90	------	------	26.76	.97353	129	87.67874	.15914
					92	1.1	33.26	26.76	.97352	129	89.62579	------
788	do	46 20	47 59	115	0	4.0	32.27	25.64	.97500	236	0	0
					28	2.0	32.85	26.27	.97427	175	27.28988	------
					56	−1.1	33.15	26.68	.97376	136	54.56230	------
					84	[1] 0.1	33.21	26.69	.97362	136	81.82562	------
					[1] 90	------	------	26.69	.97360	136	87.66728	.14768
					[1] 100	------	------	26.69	.97355	136	97.40303	.16128
					112	0.7	33.25	26.69	.97351	138	109.08539	------
789	do	46 26	47 30	205	0	3.4	33.00	26.33	.97434	170	0	0
					50	−1.4	33.30	26.81	.97366	124	48.70000	.07350
					100	−1.3	33.53	26.99	.97327	108	97.37325	.13150
					150	0.9	34.03	27.29	.97276	79	146.02400	.17826
					200	1.1	34.11	27.34	.97250	76	194.65550	.21701
					[1] 250	------	------	27.35	.97227	75	243.27475	.25476
790	do	46 26	46 57	914	0	4.8	33.66	26.65	.97404	140	0	0
					25	4.0	33.84	26.88	.97371	118	24.34687	.03222
					50	2.8	34.27	27.33	.97317	75	48.68287	.05637
					125	2.5	34.59	27.62	.97257	49	121.64812	.10300
					250	3.0	34.78	27.72	.97192	40	243.17874	.15875
					450	3.2	[1] 34.81	27.73	.97103	41	437.47374	.24025
					750	3.4	34.84	27.73	.96972	43	728.58624	.36675
791	do	46 31	46 21	404	0	6.2	34.23	26.94	.97376	112	0	0
					25	5.8	34.32	27.05	.97355	102	24.34137	.02672
					50	4.8	34.42	27.25	.97324	82	48.67624	.04974
					100	3.3	34.64	27.58	.97272	53	97.32524	.08349
					200	3.4	34.83	27.73	.97213	39	194.56774	.12925
					[1] 275	------	------	27.75	.97178	38	267.46436	------
					300	3.6	34.87	27.76	.97167	38	291.75748	.16724
					400	------	------	27.77	.97121	37	388.90147	.20448
					[1] 450	------	------	27.77	.97099	37	437.45648	.22299
792	do	46 36	45 52	276	0	7.4	34.20	26.75	.97394	130	0	0
					25	6.2	34.23	26.94	.97365	112	24.34487	.03022
					50	4.8	34.54	26.62	.97315	73	48.67987	.05337
					100	3.2	34.57	26.79	.97277	58	97.32787	.08612
					175	3.4	34.76	26.92	.97230	45	170.26799	------
					[1] 250	------	------	26.93	.97196	44	243.17774	.15775
					275	3.6	34.81	26.94	.97185	45	267.47536	------

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude °	Latitude ′	Longitude °	Longitude ′	a depth of water	a_1 depth	a = Meters: Temperature °C.	a = Meters: Salinity 0/00	a = Meters: δ_t	$a = {}_1$Pressure in decibars: V	$a = {}_1$Pressure in decibars: $V-V_1$	$a = {}_1$Pressure in decibars: E	$a = {}_1$Pressure in decibars: $E-E_1$
793	June 13	46	40	45	23	255	0	8.2	34.50	26.87	0.97383	119	0	0
							25	7.6	34.59	27.03	.97357	104	24.34250	.02785
							50	5.2	34.61	27.36	.97314	72	48.67637	.04987
							100	3.3	34.63	27.57	.97273	54	97.32312	.08137
							175	3.4	34.81	27.75	.97223	38	170.25912	-------
							250	3.6	34.94	27.79	.97186	34	243.16248	.14249
794	do	46	15	45	11	3,062	0	7.6	34.49	26.95	.97375	111	0	0
							25	7.5	34.51	26.98	.97362	109	24.34212	.02747
							50	6.4	34.55	27.17	.97332	90	48.67887	.05237
							125	5.2	34.63	27.37	.97281	73	121.65873	.11361
							250	4.0	34.77	27.62	.97202	50	243.21060	.19061
							450	3.4	34.82	27.72	.97104	42	437.51660	.28311
							750	3.6	34.84	27.72	.96973	44	728.63210	.41261
795	do	45	49	45	00	3,383	0	6.6	33.18	26.06	.97460	196	0	0
							25	5.0	33.41	26.43	.97414	161	24.35925	.04460
							50	4.8	34.24	27.11	.97338	96	48.70325	.07675
							125	[1] 4.3	34.45	27.33	.97285	77	121.68688	.14176
							250	5.6	34.85	27.50	.97215	63	243.24938	.35439
							450	3.8	34.89	27.73	.97104	42	437.56838	.45989
							750	3.9	34.91	27.74	.96972	43	728.68238	.58789
796	do	45	25	45	11	3,566	0	5.2	33.07	26.14	.97452	188	0	0
							25	[1] 7.0	33.39	26.17	.97439	186	24.36137	.04672
							50	7.3	33.81	26.47	.97399	157	48.71612	.08962
							125	4.8	34.42	27.25	.97292	84	121.72525	.18013
							250	5.6	34.86	27.51	.97214	62	243.29275	.27276
							450	3.5	34.74	27.65	.97111	49	437.61775	.38426
							750	3.4	34.86	27.75	.96970	41	728.73925	.51976
797	do	45	11	45	32	3,658	0	6.4	33.14	26.06	.97460	196	0	0
							25	5.0	33.31	26.35	.97421	168	24.36012	.04547
							50	4.5	33.71	26.73	.97373	131	48.70937	.08287
							125	2.1	34.24	27.37	.97281	73	121.70462	.15950
							250	[1] 5.1	34.90	27.60	.97205	53	243.25837	.23838
							450	4.2	34.93	27.73	.97104	42	437.56737	.33388
							750	[1] 4.1	34.95	27.75	.96971	42	728.67987	.46038
798	June 14	45	39	40	19	4,663	0	15.6	35.98	26.60	.97409	145	0	0
							25	15.4	35.97	26.63	.97395	142	24.35050	.03585
							50	15.0	35.96	26.72	.97375	133	48.69675	.07025
							125	14.1	35.88	26.86	.97331	123	121.71150	.16638
							325	12.3	35.63	27.03	.97231	113	316.27350	-------
							625	8.2	35.03	27.28	.97076	92	607.73400	-------
							750	[1] 6.5	-------	27.53	.96996	67	729.02900	.80951
							925	5.0	34.92	27.63	.96909	57	898.69587	-------
799	June 17	45	09	45	50	3,670	0	7.0	34.10	26.73	.97396	132	0	0
							25	6.9	34.13	26.76	.97383	130	24.34737	.03272
							50	5.0	34.36	27.18	.97331	89	48.68662	.06010
							125	4.3	34.66	27.50	.97269	61	121.66162	.11650
							250	3.7	34.79	27.67	.97198	46	243.26599	.24600
							450	3.8	34.84	27.70	.97107	45	437.57099	.33750
							750	3.7	34.86	27.74	.96971	42	728.68799	.46850
800	do	45	03	46	09	3,658	0	5.8	33.72	26.58	.97411	147	0	0
							25	5.7	33.73	[1] 26.61	.96397	144	24.35100	.03635
							50	4.5	33.93	26.90	.96357	115	48.69525	.06875
							125	4.0	34.44	27.36	.97282	74	121.68487	.13975
							250	3.5	34.61	27.54	.97210	58	243.24237	.22238
							450	3.9	34.80	27.65	.97111	49	437.56337	.32988
							750	[1] 3.8	34.82	27.70	.96976	47	728.69387	.47438
801	do	45	18	46	18	3,566	0	6.1	33.89	26.68	.97401	137	0	0
							25	5.8	33.85	26.69	.97389	136	24.34875	.03410
							50	4.8	34.01	26.93	.97354	112	48.69162	.06512
							125	3.2	34.47	27.46	.97273	65	121.67674	.13162
							250	3.5	[1] 34.67	27.59	.97205	53	243.22549	.20550
							450	3.7	34.83	27.68	.97109	47	437.53949	.30600
							750	3.8	34.86	27.71	.96975	46	728.66549	.44600
802	do	45	30	46	36	1,829	0	5.9	33.63	26.50	.97418	154	0	0
							25	5.4	33.79	26.69	.97389	136	24.35087	.03522
							50	[1] 4.4	[1] 34.05	27.00	.97348	106	48.69299	.06649
							125	3.2	34.53	27.50	.97269	61	121.67457	.12925
							250	3.7	34.80	27.67	.97198	46	243.21625	.21626
							450	3.8	[1] 34.86	27.71	.97104	42	437.52025	.28676
							750	3.9	34.89	27.73	.96973	44	728.63875	.41926
803	June 18	45	44	46	27	1,463	0	6.4	34.08	26.79	.97391	127	0	0
							25	5.8	34.10	26.89	.97370	117	24.34512	.03047
							50	5.0	34.32	27.15	.97334	92	48.68312	.05662
							125	3.6	34.56	27.49	.97270	62	121.65962	.11450
							250	3.7	34.69	27.58	.97206	54	243.20712	.18713
							450	3.8	34.82	27.68	.97109	47	437.52212	.28863
							750	3.9	34.91	27.74	.96972	43	728.64362	.42413

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	δ_t	a_1 = Pressure in decibars: V	$V-V_1$	E	$E-E_1$
		° ′	° ′			° C.						
804	June 18	45 57	46 18	1,518	0	7.8	33.93	26.48	0.97420	156	0	0
					25	7.2	34.93	26.57	.97401	148	24.35262	.03797
					50	6.2	34.47	27.13	.97337	95	48.69487	.06837
					125	[1] 4.4	34.66	27.50	.97269	61	121.67212	.12700
					250	4.6	34.80	27.58	.97207	55	243.21962	.19963
					450	3.6	34.81	27.69	.97108	46	437.53462	.30113
					750	3.5	34.84	27.73	.96972	43	728.65462	.43513
805	do	45 55	46 41	1,481	0	6.2	34.04	26.79	.97391	127	0	0
					25	6.0	33.99	26.78	.97381	128	24.34650	.03185
					50	5.8	34.20	26.97	.97352	110	48.68812	.06162
					125	4.4	34.65	27.48	.97271	63	121.67175	.12663
					250	4.2	34.86	27.67	.97198	46	243.21488	.19489
					450	3.8	34.83	27.69	.97108	46	437.52088	.28739
					750	3.6	34.84	27.72	.96973	44	728.64238	.42289
806	do	45 51	47 15	1,463	0	5.2	33.46	26.45	.97423	159	0	0
					25	4.7	33.63	26.64	.97394	141	24.35087	.03622
					50	1.8	34.03	27.23	.97326	84	48.69087	.06437
					125	3.6	34.59	27.52	.97267	59	121.66325	.11813
					250	3.7	34.78	27.65	.97199	47	243.20450	.18451
					450	3.6	34.84	27.72	.97105	43	437.50850	.27501
					750	3.4	34.83	27.73	.96972	43	728.62400	.40451
807	do	45 31	47 23	1,829	0	6.5	33.44	26.27	.97440	176	0	0
					25	6.0	33.57	26.45	.97412	159	24.35650	.04185
					50	1.1	33.78	27.07	.97342	100	48.70075	.07425
					125	2.7	34.42	27.46	.97273	65	121.68138	.13626
					250	3.6	34.77	27.66	.97199	47	243.22638	.20639
					450	3.5	34.87	27.75	.97102	40	437.52738	.29389
					750	3.4	34.88	27.76	.96969	40	728.63388	.41439
808	do	45 15	47 10	3,352	0	6.2	33.26	26.17	.97450	186	0	0
					25	6.1	33.33	26.25	.97431	178	24.36013	.04548
					50	4.3	33.41	26.51	.97394	152	48.71325	.08675
					125	2.4	34.14	27.26	.97292	84	121.72050	.17538
					250	2.9	34.66	27.63	.97200	48	243.27800	.25801
					450	3.4	34.79	27.69	.97107	45	437.58500	.35151
					750	3.5	34.86	27.74	.96971	42	728.70200	.48251
809	do	45 10	47 40	2,670	0	9.2	33.47	25.90	.97475	211	0	0
					25	9.0	33.55	26.00	.97455	202	24.36625	.05160
					50	7.6	33.65	26.29	.97416	174	48.72512	.09862
					125	5.6	34.45	27.06	.97312	104	121.72812	.18300
					250	4.6	34.62	27.44	.97220	68	243.31062	.29063
					450	4.3	34.73	27.55	.97121	59	437.65162	.31813
					750	3.8	34.87	27.72	.96974	45	728.79412	.57463
810	June 19	45 17	48 00	2,195	0	6.0	33.21	26.16	.97450	186	0	0
					25	5.8	33.20	26.18	.97438	185	24.36100	.04635
					50	1.8	33.66	26.93	.97354	112	48.71000	.08350
					125	1.6	34.33	27.48	.97271	63	121.69438	.14926
					250	2.5	34.63	27.65	.97198	46	243.23751	.21752
					450	3.6	[1] 34.83	27.69	.97108	46	437.54351	.31002
					750	3.7	[1] 34.89	27.73	.96972	43	728.66351	.44402
811	do	45 21	48 13	1,097	0	5.8	33.56	26.46	.97422	158	0	0
					25	5.7	33.53	26.46	.97411	158	24.35412	.03947
					50	1.0	33.74	27.05	.97343	101	48.69837	.07187
					125	1.4	34.21	27.40	.97277	69	121.68087	.13575
					250	3.6	34.78	27.66	.97198	46	243.22762	.20763
					450	4.0	34.85	27.68	.97109	47	437.53462	.30113
					750	4.1	34.88	27.70	.96976	47	728.66212	.44263
812	do	45 25	48 27	973	0	5.0	33.25	26.38	.97430	166	0	0
					25	4.9	33.50	26.52	.97405	152	24.35437	.03972
					50	3.0	34.00	27.10	.97339	97	48.69737	.07087
					125	2.8	34.47	27.49	.97270	62	121.67575	.13063
					250	3.0	34.66	27.62	.97201	49	243.22013	.20014
					450	3.3	34.75	27.67	.97109	47	437.52513	.29164
					750	3.4	34.81	27.71	.96974	45	728.64963	.43014
813	do	45 28	48 40	812	0	3.9	32.89	26.14	.97452	188	0	0
					25	3.6	33.07	26.31	.97425	172	24.35962	.04497
					50	−1.4	33.30	26.81	.97366	124	48.70849	.08199
					125	[1] 0.8	33.43	27.17	.97299	91	121.70787	.16275
					250	3.2	34.37	27.38	.97224	72	243.28475	.26476
					450	[1] 3.2	34.57	27.55	.97120	58	437.62875	.39526
					750	3.4	34.74	27.67	.96978	49	728.77575	.55626
814	do	45 32	48 50	77	0	4.9	32.61	25.91	.97474	210	0	0
					19	3.1	32.72	26.07	.97450	195	18.51778	------
					38	−0.3	33.18	26.68	.97383	136	37.02692	------
					50	------	------	------	.97369	127	48.71204	.08554
					57	−1.1	33.32	26.81	.97363	124	55.52766	------
					76	−1.2	33.42	26.90	.97346	115	74.02502	------

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	Temperature	Salinity 0/00	δ_t	V	V−V₁	E	E−E₁
					a=Meters				a_1=Pressure in decibars			
		° ′	° ′			°C.						
815	June 19	44 43	49 04	400	0	4.4	32.81	26.02	0.97464	200	0	0
					25	4.3	32.85	26.07	.97448	195	24.36400	.04935
					50	−1.1	[1]33.09	26.63	.97383	141	48.71787	.09137
					100	−1.2	33.41	26.89	.97325	106	97.39487	.15312
					175	−0.6	83.67	27.08	.97284	99	170.37325	-------
					275	1.2	34.08	27.31	.97219	79	267.62475	-------
					400	2.2	34.44	27.53	.97143	59	389.10100	.40401
					450	------	-------	[1]27.58	.97117	55	437.61600	.38251
816	do	44 40	48 49	897	0	5.7	33.28	26.25	.97442	178	0	0
					25	5.6	33.58	26.50	.97407	154	24.35612	.04147
					50	4.6	34.29	27.17	.97332	90	48.69849	.07199
					125	1.6	[1]34.44	27.57	.97262	54	121.67124	.12612
					250	2.4	[1]34.67	27.69	.97195	43	243.20687	.18688
					450	3.0	34.73	27.70	.97106	44	457.50787	.27438
					750	3.4	34.81	27.71	.96974	45	728.62787	.40838
817	do	44 39	48 36	2,012	0	6.8	33.10	25.97	.97409	205	0	0
					25	6.6	33.28	26.14	.97441	188	24.36375	.04910
					50	0.0	33.46	26.89	.97358	116	48.71374	.08724
					125	4.4	34.43	27.30	.97288	80	121.70599	.16087
					250	4.2	34.80	27.60	.97204	52	243.26349	.24350
					450	4.1	34.86	27.68	.97109	47	437.57649	.34300
					750	4.0	34.92	27.74	.96972	43	728.69798	.47849
818	June 20	44 35	48 12	3,383	0	6.8	33.08	25.95	.97470	206	0	0
					25	6.2	33.21	26.13	.97432	179	24.36275	.04810
					50	5.2	[1]33.99	26.87	.97360	118	48.71300	.08650
					125	4.7	34.43	27.27	.97291	83	121.70713	.16201
					250	4.6	34.78	27.57	.97208	56	243.26901	.24902
					450	4.0	34.83	27.67	.97110	48	437.58701	.35352
					750	4.2	34.94	27.73	.96973	44	728.71151	.49202
819	do	44 02	48 18	3,018	0	11.1	33.58	25.67	.97497	233	0	0
					25	11.0	34.22	26.18	.97438	185	24.36687	.05222
					50	9.2	34.69	26.86	.97362	120	48.71687	.09037
					125	7.5	34.73	27.15	.97303	95	121.71625	.17113
					250	6.0	34.82	27.43	.97221	79	243.30375	.28376
					450	4.7	34.90	27.65	.97112	50	437.63675	.40326
					750	4.2	34.92	27.72	.96974	45	728.76575	.54626
820	do	44 02	48 35	3,126	0	10.8	34.01	26.06	.97460	196	0	0
					25	10.6	34.02	26.10	.97445	192	24.36313	.04848
					50	3.6	33.89	26.95	.97353	111	48.71288	.08638
					125	6.4	34.75	27.32	.97286	78	121.70251	.15739
					250	5.3	34.88	27.56	.97209	57	243.26189	.24190
					450	[1]4.6	34.92	27.68	.97110	48	437.60089	.36740
					750	4.0	34.90	27.72	.96980	51	728.73589	.50240
821	do	44 02	48 50	1,993	0	5.5	33.11	26.13	.97453	189	0	0
					25	5.5	33.25	26.25	.97431	178	24.36050	.04585
					50	3.9	33.76	26.83	.97364	122	48.70988	.08338
					125	2.6	34.40	27.45	.97273	65	121.69876	.15364
					250	3.0	[1]34.69	27.65	.97198	46	243.24314	.22315
					450	3.3	34.78	27.69	.97107	45	437.54814	.31465
					750	3.4	34.80	27.71	.96973	44	728.66814	.43465
822	do	44 02	49 01	627	0	5.0	32.84	25.98	.97468	204	0	0
					25	3.8	32.86	26.17	.97439	186	24.36378	.04913
					50	−0.2	33.09	26.60	.97386	144	48.69191	.06541
					125	0.0	33.74	27.11	.97305	97	121.70104	.15592
					250	------	-------	27.32	.97230	78	243.28442	.26443
					325	1.8	34.29	27.44	.97184	66	316.18967	-------
					625	2.8	34.64	27.63	.97030	46	607.51067	-------
					750	------	-------	[1]27.65	.96978	49	728.76566	.53217
823	do	44 02	49 12	225	0	4.3	32.74	25.98	.97468	204	0	0
					25	0.2	32.66	26.23	.97433	180	24.36263	.04798
					50	1.1	33.26	26.66	.97380	138	48.71426	.08776
					100	−0.8	33.49	26.94	.97331	112	97.34201	.10026
					150	−0.9	[1]33.72	27.12	.97292	95	145.94775	.10201
					225	−0.6	33.96	27.31	.97238	75	218.89651	-------
					250	------	-------	[1]27.45	.97217	65	243.20339	.18340
824	do	43 49	48 56	813	0	4.7	32.97	26.11	.97455	191	0	0
					25	4.4	33.11	26.26	.97430	177	24.36063	.04598
					50	1.6	[1]33.47	26.80	.97367	125	48.70726	.08076
					125	1.3	34.17	27.38	.97279	71	121.70051	.15539
					250	2.6	34.61	27.62	.97201	49	243.25051	.23052
					450	3.0	34.72	27.68	.97108	46	437.55951	.32602
					750	3.4	[1]34.81	27.72	.96972	43	728.67951	.44602

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters: Temperature	a = Meters: Salinity 0/00	a = Meters: δ_t	a_1 = Pressure in decibars: V	a_1 = Pressure in decibars: V−V₁	a_1 = Pressure in decibars: E	a_1 = Pressure in decibars: E−E₁
		° ′	° ′			°C.						
825	June 20	43 35	48 39	2,951	0	7.2	33.14	25.95	0.97471	207	0	0
					25	3.0	33.73	26.89	.97370	117	24.35513	.04048
					50	1.6	34.04	27.25	.97324	82	48.69188	.06538
					125	1.2	34.39	27.56	.97262	54	121.66163	.11651
					250	[1] 2.8	34.68	27.66	.97198	46	243.19913	.17914
					450	3.3	[1] 34.78	27.70	.97106	44	437.50313	.26964
					750	3.6	34.88	27.75	.96970	41	728.61713	.39764
826	do	43 25	48 43	2,895	0	6.8	33.08	25.95	.97471	207	0	0
					25	4.4	33.26	26.38	.97420	167	24.35513	.04048
					50	2.4	34.12	27.25	.97324	82	48.69813	.07163
					125	2.2	34.47	27.55	.97264	56	121.66863	.12351
					250	2.8	34.69	27.67	.97197	45	243.20676	.18677
					450	[1] 3.2	34.76	27.70	.97106	44	437.50976	.27627
					750	[1] 3.3	34.87	27.75	.96969	40	728.62226	.40277
827	June 21	43 14	48 46	2,090	0	6.0	33.06	26.04	.97462	198	0	0
					25	3.4	33.50	26.67	.97391	138	24.35663	.04198
					50	2.4	34.07	27.21	.97328	86	48.68401	.05751
					125	2.5	34.46	27.51	.97268	60	121.65751	.11239
					250	3.0	34.69	27.65	.97198	46	243.19876	.17877
					450	3.2	34.77	27.69	.97107	45	437.50376	.27027
					750	3.4	34.83	27.72	.96972	43	728.62226	.40277
828	do	43 18	49 03	1,207	0	6.1	33.33	26.25	.97442	178	0	0
					25	5.2	33.66	26.61	.97397	144	24.35488	.04023
					50	3.4	34.09	27.14	.97335	93	48.69626	.06976
					125	[1] 2.4	34.47	27.54	.97265	57	121.67126	.12614
					250	2.8	[1] 34.68	27.66	.97198	46	243.21064	.19065
					450	3.0	34.75	27.70	.97106	44	437.51464	.28115
					750	3.2	34.83	27.75	.96969	40	728.62714	.40765
829	do	43 20	49 20	343	0	4.4	33.01	26.22	.97445	181	0	0
					20	3.8	[1] 33.05	26.27	.97431	176	19.48760	.03565
					70	−0.5	33.34	26.81	.97358	125	68.18485	.11090
					120	−0.4	33.71	27.10	.97308	98	116.85135	-------
					150	------	-------	27.18	.97286	89	146.03960	.19386
					220	+1.1	34.12	27.35	.97236	72	114.12265	-------
					250	------	-------	27.40	.97222	70	243.24022	.22023
					340	1.8	34.33	27.47	.97173	65	330.77010	-------
830	do	43 24	49 32	150	0	5.6	32.74	25.84	.97481	217	0	0
					25	3.0	32.94	26.26	.97430	177	24.36387	.04922
					50	0.7	33.20	26.64	.97382	140	48.71537	.08887
					100	−0.6	33.44	26.90	.97335	116	97.39462	.15287
					125	------	-------	26.96	.97319	111	121.72637	.18125
					150	0.9	33.66	26.99	.97306	109	146.05449	.20875
831	do	43 08	49 46	100	0	5.7	32.94	25.98	.97468	204	0	0
					25	0.8	33.20	26.63	.97395	142	24.35787	.04322
					50	−0.9	33.39	26.86	.97361	119	48.70237	.07587
					75	−1.0	33.52	26.97	.97340	109	73.03999	.10445
					100	−1.0	33.54	26.98	.97328	109	97.37349	.13174
					125	------	-------	27.00	.97315	107	121.70386	.15874
832	do	43 02	49 35	1,150	0	5.2	33.01	26.09	.97457	193	0	0
					25	3.9	33.03	26.25	.97431	178	24.36100	.04635
					50	1.3	33.35	26.69	.97377	135	48.71200	.08550
					125	−0.6	33.68	27.08	.97308	100	121.71887	.17375
					250	1.6	34.33	27.46	.97216	64	243.29637	.27638
					450	2.8	34.61	27.60	.97116	54	437.62837	.39488
					750	3.3	34.84	27.74	.96971	42	728.75887	.53938
833	do	42 56	49 21	1,545	0	5.6	33.01	26.05	.97461	197	0	0
					25	3.1	33.13	26.40	.97417	164	24.35975	.04510
					50	−0.5	33.38	26.84	.97363	121	48.70725	.08075
					125	+1.2	33.96	27.21	.97295	87	121.70400	.15888
					250	2.6	34.60	27.61	.97202	50	243.26462	.24463
					450	3.2	34.74	27.67	.97110	48	437.57662	.34313
					750	3.4	34.83	27.73	.96972	43	728.69962	.48013
834	do	42 42	49 05	2,286	0	6.8	32.98	25.87	.97478	114	0	0
					25	3.6	32.92	26.19	.97437	184	24.36437	.04972
					50	−0.3	33.25	26.73	.97373	131	48.71562	.08912
					125	−0.6	33.64	27.05	.97310	102	121.72174	.17662
					250	1.7	34.16	27.34	.97228	76	243.30799	.28800
					450	3.1	34.75	27.69	.97108	46	437.64399	.41050
					750	4.0	34.92	27.74	.96972	43	728.76399	.54450

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1927—Continued

Station	Date	Latitude	Longitude	a depth of water	a_1 depth	a = Meters			a_1 = Pressure in decibars			
						Temperature	Salinity 0/00	δ_t	V	$V-V_1$	E	$E-E_1$
		° ′	° ′			°C.						
835	June 21	42 43	49 39	1,832	0	5.8	32.90	25.94	0.97471	207	0	0
					25	4.2	32.87	26.10	.97445	192	24.36450	.04985
					50	0.3	33.11	26.58	.97388	146	48.71862	.09212
					125	−1.0	33.52	26.97	.97318	110	121.73337	.18825
					250	1.0	34.01	27.27	.97235	83	243.32899	.30900
					450	3.0	34.61	27.59	.97116	54	437.67999	.44650
					750	3.6	34.82	27.70	.96975	46	728.81649	.59700
836	June 25	43 10	50 11	78	0	8.2	32.93	25.67	.97497	233	0	0
					15	7.8	32.98	25.74	.97483	226	14.62350	.03436
					35	3.7	33.07	26.31	.97420	171	34.11280	.07306
					55	1.8	[1]33.31	26.56	.97387	147	53.59350	.10496
					75	1.7	33.85	26.82	.97354	121	73.06760	.13206
					125	------	------	[1]27.07	.97309	101	121.73335	.18823
837	do	42 55	50 09	225	0	7.0	32.87	25.76	.97488	224	0	0
					25	3.8	33.09	26.31	.97425	172	24.36412	.04947
					75	−0.3	33.57	26.98	.97350	108	73.05787	.12233
					125	+0.8	33.81	27.11	.97305	97	121.72162	.17650
					225	2.4	34.26	27.36	.97237	------	218.99262	------
					250	------	------	[1]27.38	.97224	72	243.30024	.28025
838	do	42 42	50 06	1,792	0	5.8	32.83	25.89	.97476	212	0	0
					25	5.4	33.15	[1]26.52	.97405	152	24.36012	.04547
					50	3.8	33.40	[1]26.80	.97367	125	48.70662	.08012
					125	1.3	33.98	27.22	.97294	86	121.70449	.15937
					250	2.2	34.44	27.53	.97210	58	243.26949	.24950
					450	2.6	34.65	27.67	.97109	47	437.58849	.35500
					750	3.3	[1]34.82	27.72	.96972	43	728.70999	.48050
839	do	42 24	50 06	2,286	0	7.0	32.71	25.63	.97501	237	0	0
					25	1.8	33.11	26.49	.97408	155	24.36362	.04897
					50	−0.3	33.25	26.73	.97373	131	48.71124	.08474
					125	−1.0	33.58	27.02	.97313	95	121.71849	.17337
					250	2.0	34.15	27.31	.97231	79	243.30849	.28850
					450	3.2	34.68	27.63	.97112	50	437.65149	.41800
					750	4.0	[1]34.90	27.73	.96973	44	728.77899	.55950

[1] Interpolated.

TREASURY DEPARTMENT - UNITED STATES COAST GUARD

BULLETIN No. 17

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN - [SEASON of 1928]

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UNITED STATES COAST GUARD

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INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE

IN THE

NORTH ATLANTIC OCEAN

Season of 1928

UNITED STATES
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PLATE I.—AN UNUSUAL ICEBERG AS SEEN FROM THE BRIDGE OF THE "MODOC." THE PINNACLE TO THE LEFT OF THE ARCH WAS OVER 160 FEET HIGH. PLATE II SHOWS A VIEW OF THIS ICEBERG FROM A DIFFERENT ANGLE. MAY 9, 1928

THE INTERNATIONAL ICE PATROL

1928

The international ice patrol for the season of 1928 was carried out by the United States Coast Guard cutters *Modoc* and *Mojave*, with the *Tampa* acting as the stand-by vessel. Commander William H. Munter, in addition to being in command of the *Modoc*, was also in command of the patrol, as in 1927. Commander Cecil M. Gabbett was in command of the *Mojave*. Lieut. Noble G. Ricketts was detailed as scientific observer and remained at sea with two enlisted men as assistants throughout the patrol season, aiding the commanding officer of the vessel actually on patrol and keeping a continuous and uniform record of the patrol work for this annual report. Halifax, Nova Scotia, was the base for fuel and other supplies during the ice season. The *Mojave* and *Modoc* made alternate cruises of about 15 days each in the ice regions, the 15 days being exclusive of the 5 or 6 days occupied in going to and from base.

The duties and scientific work carried on by the patrol were, in general, similar to the practice during previous ice-patrol seasons. The objects of the patrol were laid down in the instructions issued by Coast Guard headquarters on February 29, 1928, to the commanding officers of the patrol vessels.

According to the orders the primary object was to locate by scouting and radio information the icebergs nearest to and menacing the North Atlantic lane routes, and to determine the southerly, easterly, and westerly limits of this ice by keeping in touch with it as it moved southward. Four radio broadcasts were to be sent out daily giving the whereabouts of all known ice in the vicinity of the steamer lanes. In addition to giving the location, the probable drift of the known ice was indicated when possible. Special messages were drafted and sent to any ship that inquired for special information relative to ice conditions, routes, weather, or similar matters. The successive positions of the water temperature and weather reports of the liners and other vessels were carefully watched, and whenever a ship was observed to be following a course leading toward danger the master was so advised, and routes or suitable precautions were suggested.

The secondary object of the patrol was to make scientific observations of weather, ice, and oceanic conditions. This work was imposed upon the ice patrol at its beginning in order that a greater knowledge might be had of the area about the Grand Banks, with special regard to the movement of ice. It is obvious that when more facts are known about the ice and its behavior, and the causes that lie back of

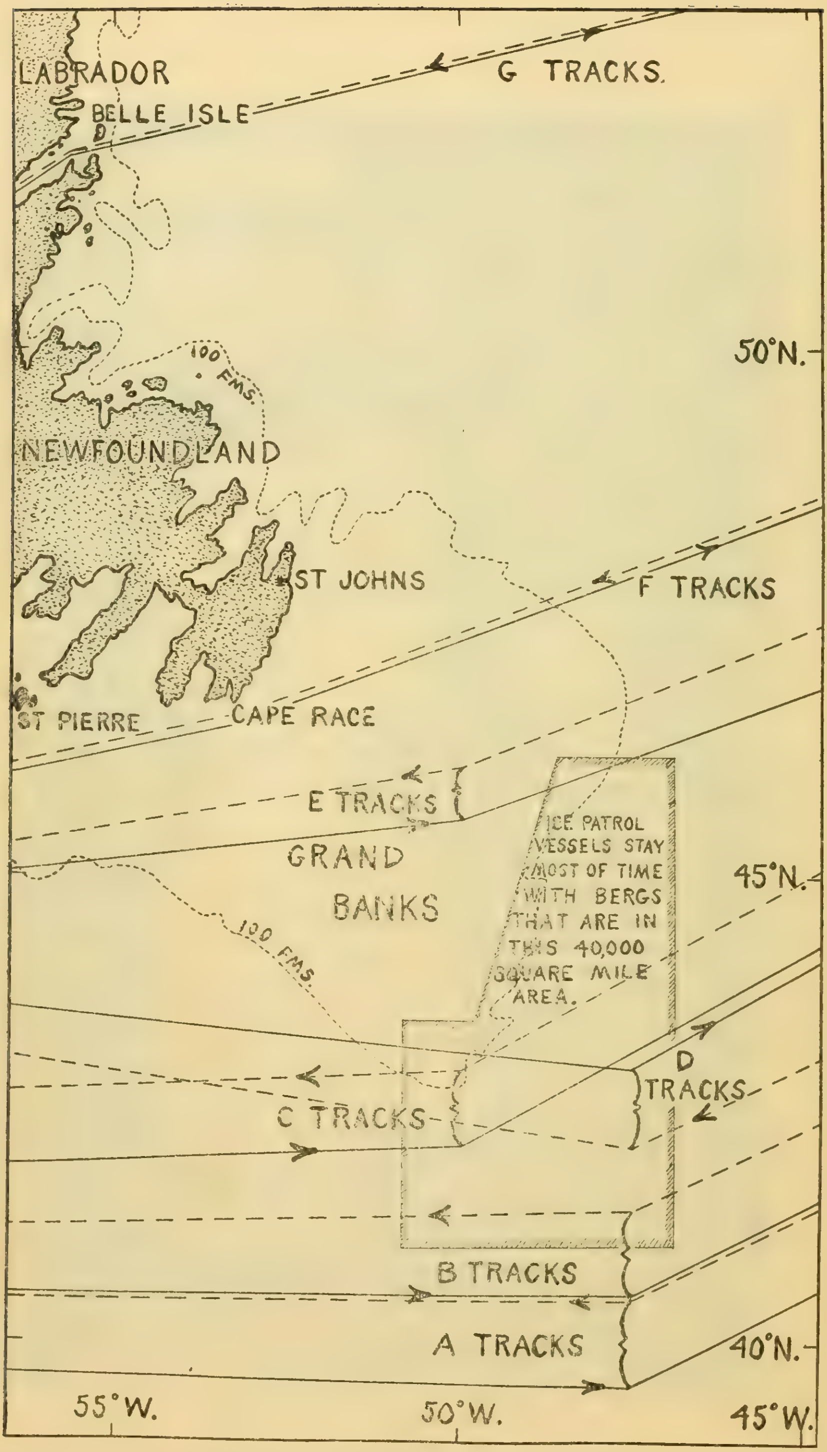

FIGURE 1.—Diagram of a portion of the principal North Atlantic Lane Routes. (For detailed explanation see next page.)

its marked variations in position and quantity from year to year, the more efficient a patrol it will be possible to maintain, and the greater will be the value of the service to shipping in general. The scientific and oceanographic work, being supportive and secondary in importance to the practical scouting and advisory work, however, was so arranged as not to hamper ice scouting and trailing.

The *Mojave* inaugurated the 1928 patrol on March 21, and from that date until the service was discontinued by a dispatch from Coast Guard headquarters on June 22, either that vessel or the *Modoc* was continually on guard in the ice regions.

Most of the vessels that ply between Europe and the United States and Canada do not follow the shortest route. That would be the great circle track and it would lead them, when plying between most ports, close past Cape Race, Newfoundland. On account of the well recognized ice menace, vessels have for many years followed established tracks, or lanes, that are shifted from time to time as the limit of the ice advances and recedes.

Figure 1 shows the approximate location of the different steamer lanes, and the explanation of the diagram shows when the different tracks are normally used. It is comparatively infrequent that the

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EXPLANATION OF FIGURE 1

A, B, and C, are routes to and from New York.
D, E, F, and G, are routes to and from Canadian ports.
Eastbound tracks are full lines.
Westbound tracks are dashed lines.
For fuller information relative to the North Atlantic lane routes see the special track charts published by the United States Hydrographic Office and by the British Admiralty.
Inclosed area between tracks E and B about the Tail of the Grand Banks shows where the distribution of the ice usually keeps the ice patrol vessel.
Normal periods different tracks are used:

A, eastbound. March 25 to July 7.
A, westbound. April 1 to June 30.
B, eastbound. February 1 to March 24, and July 8 to August 31.
B, westbound. February 1 to March 31, and July 1 to August 31.
C, eastbound. September 1 to January 31.
C, westbound. September 1 to January 31.
D. February 15 to April 10.
E. April 11 to May 15 or until Cape Race Route is clear of ice, and December 1 to February 14.
F. May 16 to opening of Strait of Belle Isle, and to November 30, when not using Belle Isle route.
G. From opening of Strait of Belle Isle to November 14.

Above so called normal periods were taken from United States Hydrographic Office chart of North Atlantic steamship routes.

A tracks were not used at all during 1928.
B tracks were used from April 14 to September 1.
C tracks were used between United States and Europe throughout rest of year.

southernmost lane, called track A, is crossed by dangerous ice. During 1928 it is known to have been crossed by bergs only twice. The tracks to the north of A are progressively more dangerous, being especially so in spring and early summer, when the Labrador current strengthens and brings large quantities of ice down from the Arctic.

Those charged with the shifting of the tracks, and those concerned in any way with the navigation of ships along them, should realize to the full, in view of the many human lives concerned and on account of the enormous value of the floating property involved, their responsibilities in the matter, and act accordingly. The prevalence of fog and low visibility over the cold water areas where the ice is usually found makes the exercise of caution necessary.

During the 1928 ice patrol season the Canadian Pacific steamship *Montrose* struck a berg along one of the Canada-Europe tracks to the northeast of the area that is most closely guarded by the ice patrol. Although she stove in her bows with the reported loss of two lives, she was able to continue to her destination under her own power. While it is not desired to view the matter in a pessimistic light, it would appear that the increasing traffic along the northern tracks leading through areas where bergs are known to be normally present in considerable numbers, is liable to result from time to time in such collisions. The ice-patrol broadcasts, which list all the known ice, when they are coupled with good judgment on the part of masters and the exercise of caution at all times, will serve to reduce these collisions to the minimum, and should greatly mitigate their serious effects when they do occur.

CRUISE REPORTS

THE FIRST CRUISE, "MOJAVE," MARCH 20 TO APRIL 5

The *Mojave* left Boston, Mass., for the ice-patrol regions at 11.50 a. m. on March 20, 1928, in obedience to orders from Coast Guard headquarters. Westerly breezes and moderate seas were experienced until a position near the Tail of the Grand Banks was reached.

While en route to the patrol grounds on the 21st, the *Halifax* wireless officer, who has charge of all the important Canadian stations in the Maritime Provinces, was notified that the 1928 ice patrol was starting. His cooperation during the coming season was requested. On the same day broadcasts to shipping were sent out to the effect that the patrol was inaugurated and that reports of water, temperatures, ice and obstructions to navigation sighted, courses speeds, and positions, were desired every four hours from all ships in the ice patrol area, which was defined as lying between latitudes 39° and 49° N. and longitudes 43° and 56° W. This broadcast was repeated every four hours until March 23, and occasionally after that in order that all vessels might be fully informed regarding the patrol.

On the 22d, regular radio schedules with NAA, the naval radio station near Washington, D. C., were established in accordance with Coast Guard headquarters' instructions. On the 22d also the Cape Race radio stations and the French station at St. Pierre, Miquelon, were communicated with and requested to cooperate with the patrol vessel as in previous years.

A cyclonic disturbance passing to the north of the *Mojave* caused lightning and warm rains on the evening of the 23d. During the day about a dozen water temperature reports were received from trans-Atlantic vessels and plotted in on the cruise chart. As time went on the number gradually increased until each four-hour watch normally produced 15 such messages.

Morning of the 24th found the *Mojave* approaching the Tail of the Grand Banks from the westward. The whole day was spent in rectangular searching for ice that carried the vessel up to and slightly around the Tail. Strong westerly winds following the "low" of the night before raised a heavy sea. No ice was sighted and the night was spent drifting in the shallow water over the Tail.

At daylight on the 25th the search for ice was resumed up the eastern edge, but fog shut in around 2.30 p. m., when a "low" approaching from the northwest caused an indraft of air from the warm water to the southward to flow over the cold water in the vicinity of the Tail. The fog caused by these southerly winds lasted until

the night of March 28 over all the cold water areas about the Banks, a very unusual condition to persist for so long so early in the season.

The ice-patrol vessel took advantage of the time while balked from ice scouting by bad visibility to run two short lines of oceanographic stations off from the Tail toward the east. It was found that a considerable body of arctic water with temperatures as low as $-1.2°$ C. was situated off the Bank, but it was calculated from the formula in United States Coast Guard Bulletin 14, that this water was all practically stationary. This suggested that farther north there was some dynamic barrier to the free flow of the Labrador current down the eastern edge of the Bank, hindering the southward extension of cold water and ice.

The time during this foggy weather that was not actually consumed by station work was spent drifting over the Bank a little north of the Tail. This area was also north of the C tracks and so out of the way of the greater part of the trans-Atlantic traffic. The inactivity was useful in that it conserved fuel and insured that later on in the cruise there would be no enforced drifting during good weather due to lack of sufficient oil.

Visibility of from three to four miles on the morning of the 29th enabled the scouting for ice to be resumed. Throughout this day the *Mojave* searched to the northward up the eastern edge of the Grand Banks. The visibility improved as the day advanced, being good from noon until dark, As might have been expected after the lifting of the fog blanket, several reports of ice came in during the day.

The steamer *M. Christensen* approaching the Banks from the eastward well to the north of the patrol vessel, reported four bergs, growlers, and field ice. It is believed that the only reason more reports of ice were not received was because there were no other ships crossing the Labrador current to the north of the *Mojave*. That there was a large volume of traffic on the C tracks to the south was evidenced by the water temperature reports pouring in from that area, at the rate now of about 70 a day. If any ice had been near the traffic lane it would have been reported along with the surface temperatures. The total absence of ice reports from vessels to the south led the patrol to conclude that the proper direction to search was northward.

Late on the afternoon of March 29 the patrol ship sighted her first ice of the season, a growler in 44° 59′ N., 48° 39′ W. Shortly afterward a growler and a berg were sighted in 45° 15′ N., 48° 21′ W., and the *Mojave* was stopped to drift by the latter for the night.

The 30th was a perfect day for ice scouting, clear and almost calm, with springlike temperatures and a gentle rolling swell. On such a day the white bergs show plainly against the dark blue water and the

light blue sky to as great a distance as the curvature of the earth will allow them to be seen, usually from 15 to 20 miles for a masthead lookout. Speed had to be limited to 70 revolutions per minute, which gave between 9 and 10 knots, because of the continuing necessity for carefully regulating fuel consumption. A rectangular area to the northeastward was covered during the day and most of the ice reported by the *M. Christensen* was checked as to position and drift. The latter was found to be about 1 knot in a southwest direction.

Two new bergs were found just south of 46° N. and just east of the forty-eighth meridian. The berg left early in the morning was reached again before dark and was watched during the night. It drifted first to the southeast and then to the east, evidently having been checked in its southwesterly course by some such shoulder of the Gulf Stream as often presses in close to the Bank a little north of the Tail, so cutting off the flow of the Labrador current. Reports of relatively high temperatures from passing vessels gave further evidence of the existence of such a shoulder of warm surface water at the time.

Ice scouting was continued on the 31st, for the winds were as light and the visibility was about as good as on the preceding day. By noon it began clouding over, due to the approach of another "low" from the west. By 3.30 p. m. the weather was thick and rainy so the searching was abandoned. During the good visibility a considerable area to the westward to the 50-fathom curve had been covered and one more unreported berg had been located. A check up was also had on the westernmost berg reported by the *M. Christensen* on the 29th, which proved to have drifted due south at about 0.5 knot.

The night of the 31st the *Mojave* spent near the newest berg, which was believed to be the southernmost ice. During the night it was lost in the storm and fog, but the next morning was found by steaming about 10 miles to windward.

The 1st of April was spent near this berg in order to follow its drift. It was the largest berg seen so far during the season, measuring about 200 feet square and averaging about 30 feet high above the water line. All the bergs sighted so far had been rounded and water glazed except where sharp cliffs were in evidence—in some places about the sides, where overhanging projections of ice had calved off.

At 4 a. m. on the 2d the patrol vessel stood to the southward to take a line of stations from a point in the warm current in toward the Bank. Seven stations were taken down to the 750 meter level during the day between the forty-eighth and forty-ninth meridians in latitude 44° 27′ N. They showed a gradual cooling of the surface water from 7° to −1.1° C. as the Bank was approached. A calculation of these stations determined the comparatively narrow width of the south-flowing stream and its approximate speed at the time and place.

To menace the United States-Europe tracks it was necessary for the ice to pass down through the narrow straitlike formation of cold water lying just off the eastern edge of the Bank. It is obvious that the narrower the band of cold water remained the easier it would be to watch and the fewer bergs would flow along it, other things being equal.

From her water temperature reports of April 1 and 2 it was noted that a steamer had passed only about 5 miles south of the southernmost berg. Steaming, as she apparently did from her successive positions, at a speed of 16.5 knots by it on a pitch dark night, it was deemed that her action was most foolhardy, especially so in view of the many factors of error that are possible in determining the position and drift of ice, and the possibility of the existence of ice not sighted or reported.

April 3 was another day of perfect visibility and light breezes like the two preceeding days. A final station was taken early in the morning on the 100-fathom curve near where the vessel had been drifting for the night. Then a run was made to the northeastward to locate ice before starting west to meet the *Modoc*. Three bergs and five growlers were sighted during the day. No less than 10 bergs were reported to the east and northeast of the Bank.

An abnormally high barometer prevailed, with gentle to moderate westerly breezes. On the morning of the 4th the wind had freshened from the west but the search was resumed at 7 a. m., and during the day the *Mojave* worked first to the westward, and then to the southward down the eastern edge. Only one berg was sighted during the day. None were reported. At 7 p. m. the vessel's head was turned to the southwest across the Bank towards the *Modoc*, which vessel was now rapidly approaching the patrol area.

During the first patrol cruise 38 ice reports were received from vessels and shore stations. Special ice information was sent on request to three steamers. There were plotted in all on the base map over 1,050 surface water temperature observations, 100 of which were made by the patrol vessel and the remainder received by radio from 130 different cooperating vessels.

The remarkable feature of the first cruise was the comparatively smooth seas and fine weather enjoyed most of the time. Except for the crisp air that almost invariably remained in the thirties and lower forties one might well have thought that the season was summer instead of early spring. One period of fog early in the cruise and two blustery but clear days were the only things that hampered the scouting and station work.

On the evening of April 5 the *Modoc* was met at a rendezvous in approximately 43° N., 53° W. There the oceanographic party was transferred and the relief of the patrol was effected by 9.30 p. m. As

soon as relieved the *Mojave* stood to the westward for Boston in accordance with authority received from headquarters on March 28. Permission to proceed to Boston instead of Halifax had been obtained because of the need of the fathometer for adjustment. The gyro-compass had broken down early in the cruise and was in need of overhaul also. The *Modoc* on taking the patrol duty over stood to the eastward toward the ice area.

THE SECOND CRUISE, "MODOC," APRIL 6 TO 21, 1928

When the *Modoc* sent a boat over to the *Mojave* to receive the oceanographic party at 9 p. m. on April 5, 1928, the commanding officer of the latter vessel took advantage of the opportunity to call on the commander, international ice patrol, on the *Modoc* for a conference. There was a light southeast breeze with a moderate northwest swell. Searchlights lit up the white patrol ships and helped the moon to illuminate the transfer activities. Mail, baggage, Navy moving picture programs, and several enlisted men were transferred from one vessel to the other.

The *Modoc* rounded the Tail about noon of April 6 and then started a search for bergs up the eastern edge. On the afternoon of the 6th and on the 7th and 8th perfect weather for scouting prevailed. The winds ranged from gentle breezes down to a flat calm, and the visibility was excellent. The heavenly bodies were practically always available for sights to locate the ship's position. Coupled with the radio bearings received at 6 a. m. and 6 p. m. from Cape Race and with the depths from the fathometer the sights made the position of the ship as certain as it could well be in an area of conflicting currents.

A large rectangle 50 miles wide and 80 miles long up the eastern edge was combed over for ice. That none was seen can be taken as conclusive evidence that there was none there. The southernmost bergs sighted by the *Mojave* had either been curved off to the northeast by the press of Gulf Stream water that was eddying in toward the bank around 44° 30′ N., 48° 30′ W., or forced inshore onto the Bank lower down by the same influence. Twilight and dawn fixes showed on the 6th and 7th the tendencies for night drifts to set to the westward when over the Banks and to the northeast when farther offshore.

On the afternoon of the 8th, about an hour before sunset, three French fishing vessels were intercepted on their slow way to the fishing grounds north of the Tail. The easternmost of them proved to be the barkentine *Bengali* of St. Servan. This vessel was given its position. It was circled and photographed while it put off a dory with mail to be posted. The *Bengali* was already 30 days out from France. She was reported to the French radio station at St. Pierre,

Miquelon. Shortly after this vessel was left a fog bank to the westward was entered. Immediately the *Modoc* stopped, to drift for the night, further searching being useless.

The three days of high barometer and fine clear weather were followed by a falling barometer accompanied by southerly winds and dense fog. This was plainly due to the passage over Newfoundland of the cyclonic disturbance that had been noted on the weather map for several days, making its way across the Mississippi Valley, the Lakes, and the St. Lawrence regions. It was so far away that the strongest winds experienced by the patrol were only force six from the south. These occured on the night of the 8th a little after the lowest barometer reading of 29.83 was noted. Up at Belle Isle at this time the barometer read 29.24. The patrol vessel had escaped another storm almost untouched on account of being well to the south of the storm track.

During the fog on the 9th four oceanographic stations were taken between the forty-eighth and forty-ninth meridians in latitude about 44° 30′ N. The patrol vessel steamed at slow speed, about 50 revolutions per minute, to the westward between stations. It was thought that the westernmost station would be in the shallow waters over the Bank, but, due to the easterly drift during the night of the 8th while offshore, it was found that the fourth station was located on the 1,000-fathom curve. After it had been taken the vessel was forced to drift by the approaching darkness. The stations served not only to indicate the dividing line between the cold and warm current, but also to familiarize the boatswains mates and the seamen of both watches with what was expected of them during station work.

On the 7th and 8th, reports of ice were received from vessels on the westbound C tracks in the neighborhood of 44° 30′ N., 46° 10′ W. These tracks were considered dangerous in consequence, and a special broadcast so stating and giving the reported positions of the bergs was sent out several times.

During the night of the 9th the fog cleared as the wind hauled more to the westward. An area of high pressure was noted on the weather map off the Middle Atlantic States, indicating a short spell of good weather for the ice-patrol area.

At sunrise on the 10th the patrol vessel began standing due north up the heart of the Labrador current. At noon the course was changed to 44° true in order to run along about 10 miles outside of the 100-fathom curve of the eastern edge. In spite of vigilant lookout and good visibility no ice was sighted until 3.30 p. m., when a large berg was observed nearly dead ahead and about 10 miles off.

This berg was the first glacial ice that many on board the *Modoc* had seen. It was a stable looking berg with old water lines and much mass. There was one pyramidal pinnacle that was separated

by a wave washed trough from the main plateau of the berg. It was circled and photographed but a snow squall came up at this time and prevented the getting of good pictures.

The northeasterly course was continued. After running about 12 miles another berg was reached and drifted by for the night in 45° 58′ N., 47° 46′ W. While running between these two bergs a whale was collided with. Being struck a glancing blow no perceptible jar was felt on board, although the large creature was rolled over and seen to scrape along the ship's side.

The 11th was spent running to the southeastward and eastward before a fair wind to investigate bergs that were being continually reported along the C tracks between the forty-fourth and forty-fifth meridians. One berg was sighted at about 11 a. m. on the port beam. Its position was cut in but it was not approached because it was not the southeasternmost ice. On the morning of the 12th the search was resumed and the berg especially being looked for was found at 1 p. m. It was circled and used as a point of aim during general quarters. This berg was low like a monitor and much eroded. The water it was floating in was of a temperature of about 56° F. The swells were giving it such a good washing with this warm water that it was not expected to last long.

The remainder of the 12th was spent searching for ice to the southward. One growler was found, probably the remains of what had been reported by steamers as a berg for several days past. The first berg, being larger and much more dangerous was returned to and drifted by until morning.

During the night no less than three steamers were seen approaching on the courses that would have carried them close to the berg. They were warned by blinker and searchlight of its presence and all of them altered their courses and passed clear.

In the morning the berg was seen to have drifted to the southeast at about 0.7 knot. It was very small now and would not remain a menace to shipping many hours longer. Accordingly, at daylight it was left and a course was shaped to the westward through a different area than had been covered on the previous two days. No ice was sighted, but the berg left was reported twice during the afternoon by passing vessels on the C tracks. The last report placed it in 44° 11′ N., 43° 21′ W. It was never heard of afterwards, so must have melted entirely during the night of the 13th.

The 14th was a day of increasing easterly winds that reached fresh gale force in the afternoon. The course toward the Banks was continued before the wind. Three oceanographic stations were taken during the day in the warm water, but the wire slanted off to windward too much for accurate results.

At 1.30 p. m. the vessel was stopped and Titanic memorial services were held in the gale. No berg was at hand this year, but the rough sea and howling wind made a fitting background for the ceremonies observed on this, the sixteenth anniversary of the great marine tragedy that created the ice patrol. An account of these exercises was radioed to the press as in previous years.

On the 13th the *Modoc* received inquiry from the press relative to news concerning the German trans-Atlantic fliers. A double lookout was kept from aloft for sight of them. When it was learned that they had landed in the Strait of Belle Isle it was realized that they were too far away and beset by too much ice to be assisted by the patrol vessel.

On the 14th also the C tracks were ordered discontinued by the North Atlantic Track Conference. The B tracks were made effective, much to the relief of the patrol vessel. The unusual southeasterly drift of ice this year had menaced the more northerly C tracks for some days. Every broadcast for some time prior to and after the 14th contained warnings to vessels that the C tracks were crossed by bergs and that extreme caution should be used between the forty-second and forty-seventh meridians during darkness and other times of bad visibility.

While the *Modoc* drifted on the night of the 14th the wind backed to the north and then gradually moderated as the "low" that had passed near by moved further out over the ocean. The whole of the 15th was spent scouting in the mixed water just east of the Banks trying to locate again the southernmost bergs in the central branch of the Labrador Stream. These waters were noted to be of a brownish color like weak cypress water. The color was especially noticeable because of its contrast with the warm blue waters of the Gulf Stream drift that had surrounded the ship for the past three days.

At 5.30 p. m. two large bergs were reached in 45° 03′ N., 48° 22′ W. These were circled and photographed in the light of the late afternoon sun. A station taken just clear of the bergs showed that the water at all levels was above the freezing point. Gulf Stream influence, even here, was therefore apparent.

On the morning of the 16th it was foggy at times, due to the winds having shifted to the southeast. The two bergs were still in sight to the northeast during clear intervals, distant about 6 miles. A station was taken at 9 a. m. that showed the *Modoc* to have been blown during the night into purer arctic water. The temperatures at the surface and down to 125 meters were between $-0.6°$ and $-0.2°$ C. The day was gloomy and misty, altogether unsuitable for scouting, so 10 miles were run to the westward and there another station was taken in even colder water, probably near the axis of the

Labrador current. When this station was finished a berg about 5 miles to the northwest was approached and examined.

This one proved to be a large picturesque berg. The blue tints and streaks in the ice were very striking. Peaks at two ends were seen to be cracked and apparently ready to fall, but whistle blasts and the reports from several blank 6-pounder charges failed to dislodge any ice. This berg was seen to have a distinct line of brownish yellow dirt in it as noticeable and as even as the caramel icing between the layers of a white cake. It was surmised that this was due to dust deposited on the ice cap in Greenland at some time in the past, possibly after a great volcanic eruption. The berg was very stable and had an old deeply worn-out water line around it, with spray glazed ice just above.

Three large birds, different from the regular species of sea birds about, were noted. These were perched on the high parts or on sheltered niches far up on the berg. When the ship got close they were found to be snowy owls that somehow had become passengers on this moving block of ice and been carried far from their arctic home.

A little to the westward a station showed only 32 fathoms of water. All of it was cold arctic discharge from $-0.6°$ to $-1.0°$ C. During the remainder of the day and throughout the night the ship drifted on the Bank in the rain. A gradually rising wind and a falling barometer were experienced.

Since the 10th many reports of ice had been coming in from steamers. No less than 17 reports were received on the 15th and one of these was from a steamer just northeast of the Banks that reported nine bergs along her course for the day. Two other vessels on parallel courses, 40 and 65 miles south of her, reported altogether 11 bergs during the day.

The ice had become much too voluminous to permit the listing of all the separate bergs in the broadcasts, so the practice of summarizing conditions in certain areas was resorted to. This expedient permitted the shortening of broadcast to practicable lengths. Whenever, as frequently occurred, ships would ask for special reports of ice along their courses their tracks would be laid down on the ice chart and messages would be immediately framed for their particular needs, giving the reported locations of all the bergs near their tracks.

On the 12th the *Montcalm* began the Canadian ice patrol in the Gulf of St. Lawrence. A day or two later the first steamer bound for the gulf and river ports was noted approaching the Banks.

By daylight on the 17th it was blowing fresh from the north, but the visibility was good. A search to the east and south off the Bank was made during the day. Three bergs were sighted in the deep water. On returning to the Bank for the night the two bergs

first sighted on the 16th were relocated and approached, to be drifted by until morning. The southernmost of the pair was now in 44° 52′ N., 49° 10′ W. It had drifted due south at about 0.5 knot for the past two days and was believed to be the southernmost ice. Considerable calving and erosion had taken place during the past 24 hours. One of the three snowy owls seen on this berg the previous evening was missing.

On the 18th the search for ice was resumed first to the east and then to the south down the Labrador current. No ice was sighted until toward evening, when two bergs reported earlier in the day by the *Berlin* as in 43° 43′ N., 48° 45′ W., were reached. Ice so far south was not expected. These bergs must have slipped down in the cold current during the *Modoc's* cruise to the eastward from the 12th to the 14th. During the night a rather severe storm of small proportions passed over, no doubt a secondary of the big "low" noted over Belle Isle.

During the blow several dovekies were picked up from deck in a stunned and bewildered condition from having been dashed against the deck house.

The two southernmost bergs were located again on the morning of the 19th and then approached and examined. Both were rather small and were drifting south about 12 miles per day according to radio bearings, dead reckoning, and soundings. Clouds prevented the accurate determination of position. A run was made to the south but no more bergs were sighted. The visibility was excellent after the storm. At 10 a. m. a course to the northwest was laid which was changed to the southwest for the Tail at 1 p. m.

After steaming about two hours on this last course, the masthead lookout sighted a berg three points forward of the port beam. It was headed for, proving to have been 15 miles distant when first seen. The berg was a solid low one that bore no resemblance to the dry-dock type whatever, being about 30 feet high and with cliff-like perpendicular sides. This berg was the southernmost ice sighted or reported so far this year, being in 43° 16′ N., 49° 14′ W. A southwesterly course was continued from the berg for 18 miles, when the course was changed to west for the Tail. The night of the 19th was spent drifting in the shoal water.

On the 20th four oceanographic stations were occupied, three of them over and one to the south of the Tail. Pure arctic discharge was observed at the bottom in the shoal water and down to the 125-meter level in the deep water to the south. At 2 p. m. the vessel was hove to on a WSW course on account of a SW gale with heavy swell.

The *Mojave* was met at 8 a. m. on April 21, 1928, in 43° N. 52° W., where the relief of the patrol was effected, As soon as the duty was turned over, the *Modoc* was headed for Halifax.

During the second cruise the weather was rather good on the average for the season until the storm of the 20th. Winds of gale force were experienced on seven different days, but lasted only about 40 hours in all, as the storms were of a very brief nature. The storm of the 20th was most inconvenient, for coming as it did toward the end of the cruise, the heavy swell remained to make the boating incident to relief of patrol quite nasty.

Visibility was good about 75 per cent of the time. Bergs were noted unusually far to the southeast and east during this cruise period. Altogether 123 ice reports were received from ship and shore stations. Special ice reports were sent out on request to 18 vessels. The isotherms on the cruise chart were largely based on the 713 water temperature reports sent in by 113 vessels. No derelicts were reported during the second cruise, but a log was reported from on the Banks and two buoys and two alleged floating mines were reported from the waters south of the Banks area.

THE THIRD CRUISE, "MOJAVE," APRIL 21 TO MAY 6, 1928

The *Mojave* at 8 a. m., on April 21, 1928, reached the *Modoc's* position in approximately 43° 00′ N., 52° 00′ W. There the ice observation party and the patrol records were received on board with some little difficulty, due to the heavy swell that was running.

As soon as the patrol was relieved the *Mojave* set a course of 90° true to relocate the southernmost berg last seen by the *Modoc* in 43° 16′ N., 49° 14′ W. Visibility remained good on the 22d, so the search was continued on that date during the hours of daylight. The berg was not found south or southeast of the Tail, nor was any other ice sighted there.

Reports of ice coming in from shipping slackened noticeably during the first part of the third cruise. On the 22d one of the four ice reports received was that of a long low berg in 43° 09′ N., 49° 17′ W. This was suspected of being the *Modoc's* berg of the 19th. It was headed for on the morning of the 23d and reached at 9.30 a. m., being sighted by the lookout aloft when it was about 15 miles off and nearly dead ahead. It was recognized positively as the berg especially being searched for. It had changed but slightly in appearance in the four days since it was left by the *Modoc*.

The berg was used as a point of aim during general quarters and then the remainder of the day was spent searching in the waters of the Labrador current to the northwest up to the Bank and back. No ice was found, though a strong southerly set was encountered with surface water temperatures well below 32°. The southernmost berg was drifted by during the night of the 23d. On the 24th an all-day search to the north and northeast and return revealed no ice.

Evidently the berg being watched was a large solitary one located well to the south of its fellows. Its drift was very interesting. It seemed first to slow down and then to speed up again in a southerly course. It stopped in its career on the 25th and worked slowly to the northwest, then to the west at the rapid rate of 0.75 knot, only to slow up for a couple of days when it had reached a position just south of the Tail.

On the 25th it was foggy part of the time. Three stations were taken at strategic points about the berg that at noon was in 42° 47′ N., 49° 22′ W. At one time during the day a start was made for the French fishing vessel *Madiana* reported by a passing freighter, the *West Zeda,* as 400 miles to the eastward with two seriously injured men on board, both with broken bones. The master of the *West Zeda* was advised by radio what to do until a doctor arrived. The *Tuscania* eastbound, was near the *Madiana.* When it was learned that she had turned about to the westward and would give medical aid very soon, the *Mojave* stopped and resumed station work. This was the second case, during the third ice patrol cruise, where medical advice was furnished by radio to ships without doctors. On the 21st treatment had been prescribed for the chief officer of the *Vogtland* who was suffering from a leg badly hurt by a boarding sea.

The 26th was smooth and sunny but foggy. It cleared up around noon and a search was started for the southernmost berg, but no ice was found until noon on the 27th. Then the berg was relocated in 42° 49′ N., 50° 10′ W., 36 miles west of where it had been seen 48 hours earlier.

The 28th was a beautiful, smooth, clear day because a high pressure area with shallow gradients was over the Banks region. The berg was drifted by all day. Boats were sent out for drill and recreation, as had been done on the previous afternoon. Very little change in the size of the berg could be noticed in the nine days during which it had been under observation. The water it was in was well below the freezing point at all intermediate levels and just a little above freezing at the surface.

At 8.30 a. m. on the 28th a liner was seen racing along to the west hull down to the southward. Her name could not be ascertained. This vessel crossed the patrol area without sending in any water temperature or weather reports. Being far north of the prescribed tracks, she was evidently keeping her radio silent in order to avoid detection. At 3.30 p. m. another vessel, also westbound, passed about a mile and a half to the south of the patrol vessel and the berg. There was no danger to these passenger vessels on the bright smooth day they had, but if they had been beset by fog or darkness a very slight error in their reckoning or that of the patrol vessel standing

by the berg would have sufficed to have put them within striking distance of the southernmost known berg.

On Sunday, April 29, the berg was left early in the morning in 42° 46′ N., 50° 32′ W., in order to take oceanographic stations down to the warm water. Fog shutting in at 2 p. m. forced the abandonment of this plan. The berg left was headed for after the fourth station had been completed, but it was not relocated on account of the bad visibility. The ice patrol vessel was forced to drift blindly four and one-half days, until 4.30 a. m. on May 4, when the clearing conditions permitted the search for the southernmost berg to be resumed.

During these foggy days it was necessary to steam slowly at times to retain position near the most probable location of the berg. Soundings and radio bearings showed the drift was to leeward up over the edge of the Bank, sometimes to the northeast and sometimes to the northwest, depending on the tack on which the vessel was allowed to drift.

During the period from the morning of April 29 until the afternoon of May 5, observations of the stars and sun were possible once only, for a few hours on the morning of May 1. The ship's position was fixed wholly by means of radio bearings and fathometer soundings at all other times. The latter instrument was invaluable as an aid to navigation. The uneven bottom enabled practically as good a track of the ship's position to be kept as though sights were obtainable.

Fifteen oceanographic stations were taken during the cruise. Considerable trouble was had with the salinity testing cabinet, but it was possible to keep it repaired sufficiently to work, and the stations were all calculated on board. The currents found by computation agreed well with what was to be expected from experience in the area. On account of the prevalence of fog and of the necessity for keeping close watch on the southernmost berg, no comprehensive plan of oceanographic surveying could be carried out. The stations had to be taken here and there as opportunity offered.

The only field ice reported during the third cruise was located along the south Newfoundland coast and in the Gulf of St. Lawrence by the Canadian ice patrol vessel *Montcalm*. Seventy reports of bergs and growlers were received from 43 different ships and shore stations. With the exception of the one berg which the patrol guarded the entire cruise near the Tail, and one berg reported on the 23d as in 47° 00′ N., 40° 57′ W., most of the glacial ice was concentrated close to the line from 47° 30′ N., 46° 00′ W. to 44° 30′ N., 49° 00′ W. It probably was disintegrating slowly on account of being in cold smooth water. The weather was remarkable for the slight seas and absence of gales.

It was marred only by summer-time fog caused by southwest winds flowing from the "high" over the ocean around to the north and northeast over the cold waters about the Banks. During the foggy times the sky was nearly always clear and blue overhead.

Besides the routine broadcasts and reports to Washington special ice information was sent on request to 17 vessels. On the 2d of May her water temperature reports showed a large liner to be running in a fog at 22½ knots toward an area where the southernmost berg might be. She was warned and two extra broadcasts were sent out during the day that advised vessels westbound on B tracks to proceed with caution between the fiftieth and fifty-second meridians. These special warnings were sent out at noon and at 4 p. m. as long as the fog lasted. No derelicts were sighted or reported during the cruise. Three spars and five drifting buoys were reported as in or near the patrol area. One hundred and eighty-four vessels cooperated with the patrol by sending in 1,077 reports of sea surface temperatures.

On May 4 the weather was drizzling with visibility of about 4 miles. Search was resumed for the southernmost berg to the northwest along the 100 fathom curve of the Banks. Forty miles had been covered in this direction when a large berg was reported in approximately 43° 02′ N., 50° 40′ W. This point was headed for and reached but no berg was found, although a rectangular search was kept up until dark. The vessel that reported the berg (the *Artigas*) stated that she had not had observations for three days, and that her reckoning might be far out.

On the morning of the 5th the search was resumed around the Tail. Visibility was but little better than on the preceding day with the added handicaps of strong breezes to gales and a rough sea from the west, so at a little after 8 a. m. it was decided to run on a westerly course for the *Modoc*, then 180 miles away in 43° 00′ N., 54° 00′ W. At 6.40 p. m. visual contact was effected and preparations were made to transfer the observing party and records. The relief of patrol was effected successfully early in the morning on May 6 in approximately 42° 25′ N., 52° 00′ W., the conditions of wind and sea having been deemed too severe on the preceding evening to warrant the use of small boats except in an emergency.

THE FOURTH CRUISE, "MODOC," MAY 6 TO MAY 21, 1928

As soon as the *Modoc* took up the ice patrol duty on May 6, the search for the southernmost ice was resumed. Visibility was good, but the day was blustery and on some of the courses the ship rolled deeply to the westerly sea and swell. The Bank just west of the Tail was reached shortly after noon. A rectangular search revealed no trace of the berg reported there on the 4th. At about 6 p. m. there

was received a report of a berg 40 miles to the southeastward in 42° 27′ N., 50° 02′ W. This ice was headed for and the distance was run up before the vessel was stopped for the night.

At daylight on the morning of May 7 a low round water-washed berg was sighted near by. Three oceanographic stations were taken in the vicinity of the low berg and of another small one that was located about 18 miles to the northeast. The bergs were both in water warmer than 42° F., so were eroding and diminishing fairly rapidly. They were drifting slowly southward toward the westbound B tracks, now about 40 miles away from them.

On the 8th it was foggy most of the time due to a light southeast wind. During the intervals when the visibility was fair a few runs were made in search of the berg to the northeast of the small round one, but it was not to be found. The southernmost ice, now visibly smaller and looking like a big floating toadstool, was returned to for the night.

May 9th commenced with clear skies and a rising barometer. It was the beginning of a two-day period of good visibility, during which a large area south and southeast of the Tail was searched. Both of the small bergs being stood by were relocated. The southernmost one was found to be in 42° 08′ N., 50° 10′ W. The other had closed up on it, being only eight miles off.

These bergs were left early on the 9th. A course was laid for a berg reported in 42° 37′ N., 48° 51′W., which was seen by the patrol vessel when 22 miles away. It proved to be an immense piece of ice with pinnacles and ridges sticking up over 150 feet above the surface. With its large natural arch, and its patches of black dirt imbedded in some of the sheer walls it was a striking object in the bright sunlight. All hands gazed at it in fascination as it was circled, while the photographers on board snapped shutters with all their might.

Twenty-four reports of ice were received during the 9th. One of these listed 12 bergs about 60 miles, 70° true from St. Johns, Newfoundland. Only three bergs were reported south of the forty-sixth parallel. A westerly course was run from the arched berg for 30 miles, but no more ice was located by the *Modoc*.

On the 10th the visibility was still good. No less than 37 different messages reporting ice were received, the record for one day so far for the season. Courses were run first to the northeast, then to the northwest up to the 50-fathom curve of the Banks. This was followed to the southwest around the Tail, and then, late in the afternoon, the two small southernmost bergs were headed for.

While over the shoal water several trials were made to get bottom samples for Dr. P. D. Trask of La Jolla, Calif. His apparatus, being designed particularly for muds, failed to work on account of the sandy nature of the deposits.

Luckily both of the small bergs that were left on the 9th were found before darkness and fog closed in. They had diminished greatly during the past two days. The southernmost one was in 41° 55′ N., 50° 00′ W., and was small enough to be visibly rolling to the swell. It was believed that these bergs could not last over three days more under the existing conditions.

The 11th, 12th, 13th, and 14th were days of dense fog. The ship lay drifting in the southerly airs and breezes, forced to await better visibility before attempting to relocate the southernmost ice, or to do any extensive station work. As soon as the fog blanket settled over the cold water the reports of bergs dropped to only one or two a day. These came from the ice-infested areas north of the forty-seventh parallel. The reporting ships on the northern tracks must have been close to disaster to have obtained them. Only extreme slow speed and cautious groping, such as is not practiced generally along the less thickly ice-strewn United States-Europe tracks, could have prevented accidents along these northern lanes.

On the 12th six vessels requested special information. One of these, the Greek steamer *Cape Corso*, whose master was evidently a stranger to the fogs of the ice area, requested aid and advice no less than ten times during the day.

On the 12th, also, hundreds of small whales, probably blackfish, played in thickly grouped schools about the ship. The largest were between 25 and 30 feet long. Tiny ones were seen swimming close to the side of some of the larger ones, probably their mothers. The animals played about the ship aimlessly with slow and powerful motions for hours. There was much puffing and blowing to be heard from different directions as the groups came to the surface from time to time to breathe. Sometimes one or two would raise their heads straight up out of the water and keep them there for a moment, looking like slimy black creosoted pilings floating upright.

By the 14th the vessel had been blown by the steady winds some 70 miles against the Labrador Current up to the Tail of the Bank. During the fog the wind seemed to blow with greater force through the rigging aloft than it did down near the water.

On the 14th four oceanographic stations were taken in the shoal water about the Tail. Doctor Trask's bottom sampler was tried again but without success. In spite of the sensitive flapper valves at the top the deposit was too sandy to remain in the open-bottomed cylindrical pipe that projected downward from the central portion of the sinker.

The 15th was overcast, but good visibility prevailed once more. For nearly 15 hours the search was carried on to the southeast past where the large berg with the arch had been last reported. Thence a southerly course was run to a point where the limit of

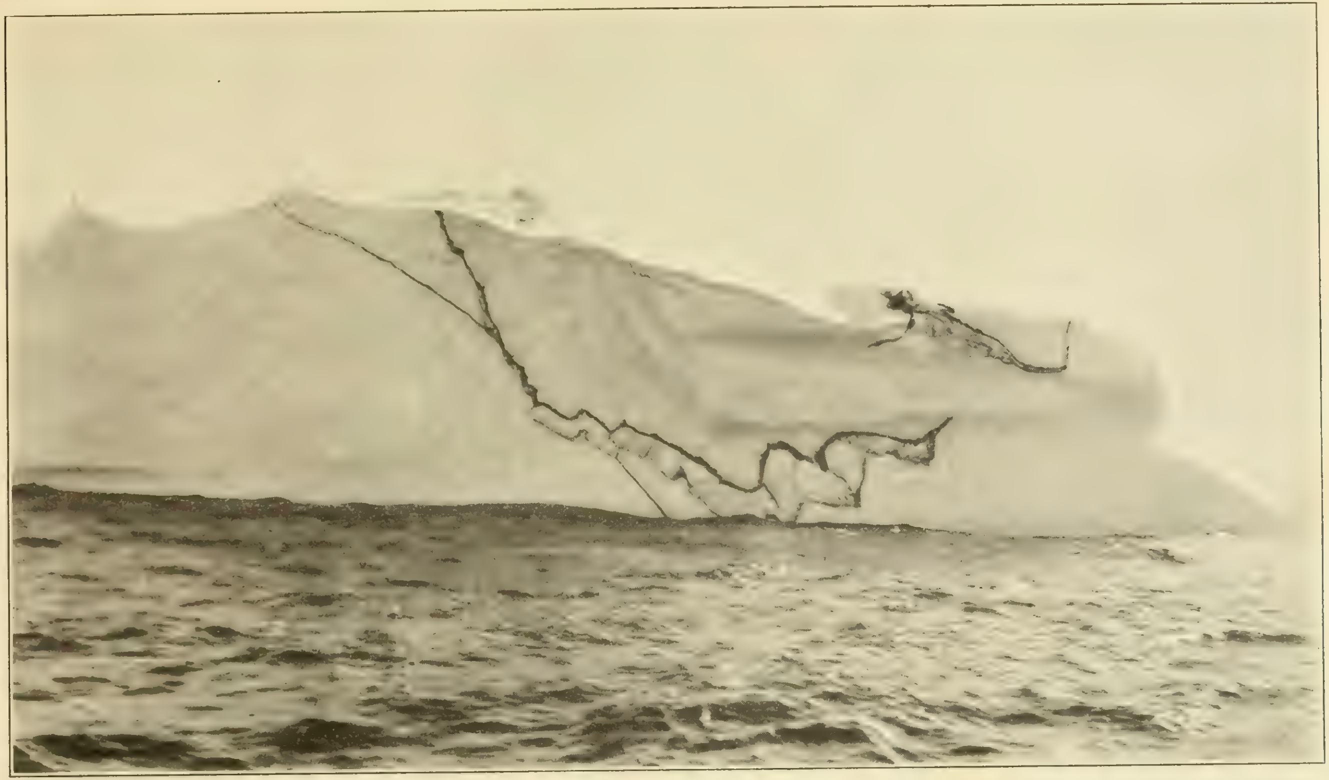

PLATE II.—THIS ICE CLIFF WAS IMPREGNATED WITH DIRT AND STONES. THE MATERIAL WAS PICKED UP BY THE ICE BEFORE IT LEFT GREENLAND AND WAS GRADUALLY DEPOSITED IN THE SEA AS THE ICE MELTED. MAY 9, 1928

PLATE III.—AN ICEBERG IN A LIGHT LOW FOG. THIS ICE WAS VISIBLE FROM THE CROW'S NEST WHEN 3 MILES DISTANT, BUT NOT FROM THE BRIDGE UNTIL LESS THAN 1 MILE AWAY. MAY 31, 1928

visibility toward the south from aloft crossed the limit of visibility toward the north of the vessels westbound on the B tracks. Until dark the search was carried on to the westward roughly parallel to these tracks. Very few reports of ice were received during the day on account of the fog's presistence farther north.

Advantage was taken of the fog, which lasted until 2 p. m. on the 16th, to take two oceanographic stations, one after the other at the same spot, to see how nearly identical the independent measurements of salinity and temperature would be at the different levels. As the results were very much alike, more confidence was felt for the accuracy of the station work done so far.

A sudden shift of the wind from northeast to west occurred around noon. Within two hours this change had cleared up the fog sufficiently to enable a course of 0°, true, to be laid towards the Tail in search for the southernmost ice. No ice was sighted. Intermittent fog hampered the scouting.

The morning of the 17th was ideal for searching, although conditions were favorable for thick weather—a light wind from the southeast with a low barometer. Thirty miles had been run up to the Tail, and thence a considerable distance to the east across the cold water had been covered by 10 a. m., before the fog shut in. The vessel stopped for an hour until it lifted. It shut in again very soon, whereupon the vessel was again stopped. A station was taken between 11.15 a. m. and noon.

During the morning a report was received from south of both the eastbound and westbound B tracks of a piece of ice only 1 foot square in 40° 19′ N., 47° 51′ W. This was believed to be the remains of the great arched berg that on the 10th was 140 miles to the north-northwest. No other report was ever received of this berg or of the two small southernmost bergs of the 10th. All of them must have melted unwatched during the fog. It was decided not to search to the southward any more for this ice but to work up the eastern edge of the Banks, searching for new bergs.

Before sunset two large bergs were found in 43° 34′ N., 49° 06′ W., and 43° 38′ N., 48° 56′ W. They were reported around noon by the *Yorck*, which vessel claimed to have had them 20 and 24 miles off when abeam. This great visibility was doubted, but when the patrol vessel approached them from the south they proved easily visible at those distances.

A short run to the Bank was made from the southwesternmost berg of the pair, but no more ice was sighted. A station was taken at dark, just inside the 50-fathom curve, where no water below 0° C. was found at any level.

On the morning of the 18th the search up the eastern edge was renewed. A berg was located at 9 a. m. in 44° 05′ N., 49° 13′ W.

Courses were run a little farther north, then east, and finally south to return to the two tall bergs seen on the preceding day. When fog shut in early in the afternoon it was realized that these bergs could not be relocated, so stations were taken in toward the Bank until 11.30 p. m.

On the morning of the 19th, it still being quite foggy, a row of six stations was run cautiously to the southeast from the shoal water in 43° 33′ N., 49° 32′ W. Arctic water was found extending east only 20 miles from the 100-fathom curve. From that point a mixed water was encountered at all levels. Forty miles southeast of the Banks the sea surface was 46° F.

At about 4 p. m. a course of 270° true was set for the Tail. Visibility was fair because the haze and fog were soon dissipated after the wind backed from Northeast to Northwest around 1 p. m. Neither of the two large bergs that were 30 miles to the north two days previously were sighted.

On the 20th the weather was still overcast and the moderate Northwest gale that commenced shortly after the wind backed on the 19th was still blowing. Search courses were run to the north and then to the west, but no ice was seen. The night was spent running slowly from the vicinity of the Tail toward the *Mojave*. That vessel was met and the relief of the patrol was effected at 9 a. m. on May 21 in 43° 00′ N., 51° 00′ W.

During the fourth cruise, 27 oceanographic stations were taken. It was found that water below 0° C. was limited in amount, being confined about the Tail to the lower levels of a narrow band. This would seem to indicate a small supply from the north. The weather was moderate but foggy. The only time that the wind attained gale force was during the storm of the 19th and 20th. Visibility of less than 2 miles was experienced during 153 hours, nearly 43 per cent of the time.

Altogether 137 ice reports were received from ship and shore stations. Six logs and minor items of wreckage were reported by steamers from south of the forty-third parallel. Three similar drifting objects were reported from farther north.

One hundred and sixty three vessels cooperated by sending in 1,153 water temperature reports. During the cruise 23 vessels were furnished special ice information on request.

Only eight different bergs were sighted or reported during the cruise south of 45° 30′ N. Those that reached the latitude of the Tail showed a tendency to drift south without curving either to the east or west. One of these, before entirely disentegrating, reached the low latitude of 40° 19′ N., in the longitude of 47° 51′ W.

Prolonged periods of fog kept the patrol vessel from following closely the final drifts of the three bergs that were seen south of the

forty third parallel. Shipping should be made to realize continually the inability of the patrol to keep in close contact with bergs during fog. This greatly increases danger along the tracks during thick periods of weather over and near the Banks.

Fully 75 bergs were reported east and northeast of St. Johns, Newfoundland, during the cruise. Almost all of these were expected to ground or to disintregrate north of the forty seventh parallel. A few would get south in the narrow stream of cold water flowing down along the eastern edge of the Banks. Dynamic computations, which checked well with recorded berg drifts, showed that in the swiftest part this stream was setting south over 24 miles per day.

Extreme southeasterly drift of bergs noted early in the season had stopped. This was accounted for by the marked extension north and northeast of the 60° and the 54° isotherms in the eastern half of the ice-patrol area. The effect of seasonal solar warming was noticeable in all the surface temperature reports that were received.

THE FIFTH CRUISE, "MOJAVE," MAY 21 TO JUNE 5, 1928

The annual surfboat race between the two ice-patrol cutters was held on the morning of May 21 in 43° N., 51° W., as soon as the *Mojave* had received the ice observation party. When the race was over the *Mojave* hoisted her defeated boat and crew and headed east on the lookout for bergs.

Visibility was better than for seversl days and the search revealed the southernmost known bergs to be in 42° 45′ N., 49° 55′ W., and 42° 42′ N., 50° 25′ W. They were last seen by the *Modoc* on the 17th and had traveled about 70 miles to the southwest in four days.

At daylight on May 22 a search was begun up the eastern edge of the Banks from these bergs. Fog was soon run into, so the course was reversed. The fog was outdistanced and, although it remained in sight to the north all day, except for a few wisps it did not again trouble the patrol vessel.

An unknown berg which was reported as in 42° 25′ N., 49° 38′ W., was run for, found, and examined. It was a small one of the dry-dock type with three distinct peaks separated by water. The sea was so smooth that this berg was examined closely from a boat. Photographs were taken of it with the *Mojave* in the background. It was not expected to last long because it was in 44° water and was crackling almost incessantly as if its ice was under great tension and stress.

The 23d was a day of glassy seas and calms. Unfortunately, it was foggy most of the time. When visibility permitted search courses were run for the solid berg seen the preceding day. It was found about 1.45 p. m. After circling it a search course was started to the west. Shortly afterwards the fog closed in thick. It was determined to

run to a point about 3 miles east of the berg before stopping to drift for the night. A course was set that it was thought would lead well clear of the ice, but soon a white radiance was seen in the fog ahead a little on the opposite bow to the one on which the berg was supposed to be. Collision with the ice was avoided by yards only by the giving of full left rudder.

On the 24th the fog continued, so no ice was seen. Better visibility prevailed further north and numerous berg reports were received from vessels on the Canadian tracks east of St. Johns. Two stations were taken during the day to try out the oceanographic equipment. It was found that although the surface water in 42° 37′ N., 51° 02′ W., was warmed to 37° F. by the sun, the water at the 50 and the 125 meter levels was about 31° F.—pure berg-bearing arctic discharge.

As there had been little wind during the foggy weather a couple of hours' run to windward with the fair visibility of the morning of the 25th sufficed to relocate the large, solid berg. Sights placed it in 42° 10′ N., 50° 46′ W., still moving southwest about 18 miles per day.

A search to the west and south failed to reveal the berg that had been in that direction from the big berg a few days previously. Sixty-two-degree water was encountered, so it was considered likely that this berg had entered the warm water and entirely disintegrated. The solid, large berg was returned to for the night.

On the 26th foggy conditions prevailed over all the cold water regions. Only two bergs were reported and none were sighted. Two oceanographic stations were taken. The next day a search was carried on for the near-by solid berg when visibility permitted. It was reported by a steamer as in 42° 04′ N., 49° 28′ W., n the afternoon. This spot was run for at 110 turns, but fog came on that forced the patrol vessel to stop before the berg was found. While taking a station at 6 p. m. a Greene-Bigelow water bottle and two reversing thermometers were lost overboard due to their being clamped too loosely to the sounding wire.

On the 28th a cold north-northeast wind reversed the recent weather conditions, giving good visibility over the cold water and fog and vapor over the Gulf Stream. A northerly course was accordingly run into clear weather where sights were obtained. These showed the vessel to be 40 miles south of her reckoning. The solid berg was found at 3.30 p. m. It had drifted in a general east-southeast direction at 1 knot for the past three days. The area of the top was smaller but the berg was still quite solid and high. There was water-line evidence of its having tipped recently due to uneven melting below water. No other bergs were found during the day.

The 29th was foggy and practically calm. A few minutes of fair visibility permitted the obtaining of sights that showed the rapid southerly drift was being continued.

On May 30th the visibility was good until 5 p. m. Just before that time, thanks to a report from a passing steamer, the berg of the 17th was found in 41° 10′ N., 48° 17′ W. It was drifting southeast 36 miles per day and was in a cold finger of arctic water that still had subfrigid temperatures 50 meters below the surface. Only a few miles away to the south was 72° Gulf Stream surface water.

West-southwest winds and fog prevailed over the cold tongue of Labrador water on the morning of May 31. A station was taken at 8 a. m. that was most disastrous. Seven bottles were sent down on the line. They had all been tripped and were being hauled up. As the first bottle approached the working platform the chief electrician's mate operating the winch made a move to stop the motor, but his hand slipped from the operating lever, and, before he could grab hold again to move it to the stop position, the upper water bottle had risen to the fair-lead block on the span near the davit heads. When it struck this block the strain immediately became so great that the wire parted and 7 Greene-Bigelow bottles, 14 reversing thermometers, 2,400 feet of $\frac{5}{32}$-inch wire rope, one 300-pound weight, and 7 "messengers" were lost. As all of the *Mojave's* best equipment was on the wire, station work was much hampered until the arrival of the *Modoc* on patrol.

It was noted that vessels but 20 miles to the south were enjoying fine clear weather, so a course of 200° true was laid for the warm water of the Gulf Stream. After running slowly for a few minutes a large growler was sighted in the fog. A little farther to windward the main berg of the 17th was found. It was seen from aloft over the low fog when 3 miles off. From the bridge it could not be seen when only 1 mile distant.

This berg was positively identified as the same one that had been trailed so long. It had rolled until its characteristically curved top now formed a perpendicular side. It looked while being approached like a great white submarine with a central cunning tower and sloping tapered ends. Clouds of vapor were being rolled from the ice by the warm wind. About 5 miles south of the berg there was no fog. There the patrol vessel drifted all afternoon, keeping watch on the berg that could be dimly seen until 6 p. m. through the mists that continued to hang low over the cold water.

Good sights taken during this time showed that the berg had drifted no less than 54 miles on a course of 80° true during the past 24 hours. As was the custom during foggy weather recently, special broadcasts were sent out every hour that gave the changing positions of the southernmost known ice, and warned vessels on the B tracks to proceed cautiously on the lookout for unknown bergs that might be coming down from the north unseen in the fog.

For over a month the extreme southerly drift of ice had necessitated the presence of the patrol in the south and had precluded the proper searching of the eastern edge of the Banks for new bergs. The few reporting vessels that had crossed the area between the Canadian tracks and the B tracks were much hampered by fog. The location and number of bergs now south of the forty-eighth parallel and between the fiftieth and the forty-seventh meridians was much in doubt. It was believed likely that many more than the eight reported and sighted since May 25 existed in this area.

On the 1st of June the patrol vessel was still south of the edge of the fog area, but the berg could not be seen. Sights taken during the morning showed the phenomenal drift of 63 miles in 19 hours. The set was now 20° true. As soon as the heat of the sun burned off the fog over the cold water a bit a search was carried on to the westward. Numerous growlers were found in the vicinity of 42° 02′ N., 46° 22′ W. These were thought to be the remnants of the berg of the 17th.

Search to the west and southwest for larger parts of the berg proved futile on account of the fog. The ice seen was in 60° water and would hardly last over night. Around 5 p. m. the growlers were returned to. They were much smaller already. A course of 225° true was run for 5 miles. Then the main berg from which the smaller pieces had been blown to leeward was found in the fog. It was low and very much cut into by the warm water, but it still possessed much mass. No resemblance to the berg being followed could be found, but it must have been that one on account of its location.

On the morning of June 2 north winds were blowing and the clear weather following a shallow "low" was enjoyed. A 20-mile run towards the west sufficed to reach the berg again. It was drifted by all day. Once around 1 p. m. the berg suddenly listed 90° when a large piece of ice broke off. In the afternoon water temperatures were taken all around the berg, some of them close to it from a boat. Sixty-degree water was found at all times. Several persons went in swimming among the growlers surrounding the berg from one of the ship's boats.

By dark the berg had become reduced to small proportions. Its highest pinnacle was about 40 feet above the water and it was about 90 feet long by 80 feet wide. Its position at 8 p. m. in 43° 00′ N., 46° 17′ W. showed that it had recurved and was now drifting away from the steamer lanes. It would certainly melt enough to cease to be a serious menace to navigation within 36 hours. Accordingly it was left. A course was run during the night to the northwest so as to arrive at a position in the cold current off the eastern edge of the Banks early on the morning of June 3.

The berg left had been trailed with great difficulty through fogs and mists for 16 days along a curving track more than 480 sea miles

long. This track was very interesting for it showed clearly the distribution of the Labrador water south of the Tail of the Banks. It is worthy to note that at the same time that the trailed berg was drifting north-northeast along a cold tongue of water, another berg was known from frequent reports to be drifting south-southwest at almost the same speed on the western edge of another cold tongue from the north. On June 2 the latter berg was reported in the very low position of 39° 39′ N., 50° 00′ W., apparently drifting south-southwest at 2½ knots. The next day it was last reported as at 38° 59′ N., 48° 51′ W., the southernmost ice reported or sighted during 1928.

Good visibility prevailed on June 3 until 5 p. m. The cold stream was thoroughly searched between 45° 15′ N. and 44° 00′ N., but no ice was located. The warming influence of Gulf Stream mixing was noted inshore to the 100-fathom curve. Water less than 40° F. in temperature was found on the surface only in a very narrow band that was crowded over onto the Banks. On this account it was believed that very few more bergs would be able to drift below the forty-fifth parallel this season.

June 4 was spent running slowly down the eastern edge of the Banks working toward a rendezvous with the *Modoc*. The fog was so dense at times that it was necessary to stop the ship.

During the fifth cruise no gales whatever were encountered. There was fog 50 per cent of the time. When it is considered that several days were spent in warm water south of the fog area and that on at least two days a knowledge of surrounding conditions enabled the patrol to dodge the fog, an idea of the difficulty of keeping in touch with the bergs in cold water during May and June can be appreciated. The patrol felt keenly the probability of the existence of unreported bergs south of the forty-third parallel, and continually warned shipping in the regular broadcasts to beware of unknown bergs. It was made routine to send out such warnings with the location of the southernmost known dangers every hour during fog and darkness.

Only six different bergs were sighted and reported south of 45° 30′ N. during the period from May 21 to June 5. It seemed as though most of these few bergs that succeeded in passing down through the narrow neck of cold water along the eastern edge of the Banks made a grand circuit counterclockwise around the edges of the cold mixed waters southeast of the Tail of the Banks. Some of these bergs tended to follow the edges of the cold tongues of water that extended from the large cold body. A conclusion to be drawn from a study of the tracks and distribution of this ice is that while bergs may be met in warm water, a cold tongue often forms a broad avenue along the edge of which bergs can readily drift along at from 2 to 3 knots.

The finding of water of 60° F. in temperature about the berg on June 2 from 2 miles away right up to within from 100 to 50 feet of it in all directions shows what little dependence can be placed upon a fall of temperature to give warning of proximity to bergs.

The smoothness of the sea during the fifth cruise prevented any very rapid disintegration of the ice seen. A steady slow dissolving was the rule. This was speeded up somewhat by calving and the consequent listing about in the warm water.

No field ice was reported during the fifth cruise. Sixty different bergs were reported by vessels from the Cape Race tracks. Only one of these was located east of the forty-ninth meridian. A tendency for the ice to drift through the Gulley and to the west past Cape Race was noted. Only a very few of the easternmost of the northern bergs were located so they could possibly get south of the Tail. It was not believed that any of them would get so far south.

The disintegration of the northern ice could not be observed as the patrol vessel was kept in the lower patrol latitudes by the few bergs south of 43° N. The continuance of solar warming in the north was noted from the reporting vessels' water temperature reports; 34° surface water had disappeared from the map. All the bergs south of 48° were undoubtedly being eaten into about the water line and calving and disintegrating at an increasing rate.

Ten oceanographic stations were taken and computed. A little more would have been accomplished except for the loss of the equipment on May 31 described above. The salinometer on board was in need of a thorough overhaul. In addition to having to be heated by makeshift methods after the burning out of the heating coils its water bath sprang a leak during the cruise and had to be taken down and resoldered.

In all 119 ice reports were received from ships and shore stations. Special ice information was furnished to 18 vessels. No derelicts were reported, but no less than 15 reports of minor items, such as logs and buoys, were received from passing ships.

Good visibility attended the final run to the westward past the Tail on the night of June 4. On the following morning at 9 o'clock the *Modoc* was met in 43° N., 53° W., and there the oceanographic party was transferred and the relief of patrol was effected.

THE SIXTH CRUISE, "MODOC," JUNE 5 TO 20, 1928

Good visibility with moderate weather conditions prevailed when the *Modoc* took over the ice-patrol duties from the *Mojave* on June 5. The day was spent running to the eastward toward the Tail. Water warmed to over 45° F. was noted all the way from 43° N., 53° W., to 43° N., 50° 15′ W. To the east of that 40° surface water from the north was encountered.

Numerous bergs were reported from the Cape Race tracks and three bergs from southeast of the Tail. The southernmost of these consisted of a pair of large bergs reported to be in 41° 25′ N., 48° 31′ W. This position was directly on the B tracks, so the *Modoc* steamed all night toward it.

The 6th and 7th were overcast and mostly calm, but the excellent visibility continued. A thorough search in which vessels on the B tracks assisted was conducted, but the two bergs could not be found. As the water was comparatively warm (from 45° F. to 66° F.) it was concluded that they had entirely melted. Two small bergs seen on the horizon by the reporting vessel on June 5 had probably been mistaken for and reported as large bergs as is often done.

The whole of daylight on June 8 was spent running back to the northeast to the Tail. It was hoped that the good visibility would continue and that the Labrador current along the eastern edge of the Banks could be searched for ice. From June 2 to 7 eight bergs had been reported along the northern end of this edge. They were no doubt moving south, some of them but how far they had moved it was impossible to tell on account of the scarcity of reporting vessels crossing the ocean between the Canada-Europe and the United States-Europe tracks.

June 9, 10, and 11 were overcast foggy days. At times the visibility was good enough to permit search courses to be run, but not much progress was made. Just about enough distance was covered to enable the scouting to stem the cold current flowing southwest past the Tail between the forty-ninth and fiftieth meridians. This current was found by the stations taken and by the actual drifts experienced to be setting to the south and the southwest about 24 miles per day. Radio bearings from Cape Race and the fathometer depths enabled pretty close check to be kept on the ship's position, even though it was possible to obtain but two sights in three days. The Labrador current was about 40° on the surface, but temperatures below 32° F. were found around the 50-meter level at two of the stations taken east of the Tail during this time.

On the 11th a 3-pinnacled berg with water separating the sections was sighted. Although the day was overcast and dull this berg was seen by the lookout aloft when 20 miles distant. It was in 43° 04′ N., 49° 00′ W. at noon. Plans to scout up to the north from it had to be abandoned when rain and fog came on. Early in the afternoon the patrol vessel returned to the berg and took two stations in its vicinity. When these were worked out they showed that the berg was drifting south or southwest and not northeast as might have been thought from its rather far offshore location.

At 2 p. m. a boat was lowered to allow the two newspaper men on board to examine a berg from close quarters. They had a great

opportunity to observe action, for when they were near it one of the three pinnacles broke from the main berg where it had been eaten into about the water line. Hundreds of tons of ice fell off into the sea with loud reports and roars. The berg did not capsize but rose up and acquired a permanent tilt of about 30° when it was relieved of the weight of one end.

A considerable amount of ice in small pieces was picked up by the boat and brought aboard. It was hard and brittle with a tendency to crack up into pieces with very irregular surfaces if struck hard or dropped. The ice itself was very clear but it contained many of the usual air bubbles, each about half the size of small common pinheads.

At 8 a. m. on June 12 while the *Modoc* was drifting in a dense fog in the vicinity of the berg sighted the previous day a report was received from the *Tampa,* a freighter, stating that they had just passed a dory with two men in it apparently lost in the fog. They were endeavoring to relocate this boat. The patrol ship immediately started for the position, about 80 miles to the northwest, to assist in the search. Before half the distance had been run the *Tampa* radioed that the weather was now clear and that no dory was in sight but that a large sailing vessel was near by. As they assumed this to be the mother ship of the dory they had resumed their course to the east. The *Modoc* was stopped to drift again in the fog.

Very soon the clear weather reached the *Modoc*. It was decided to run up the Labrador current until dark, searching for ice coming down. A strong current from the north with pronounced tide rips was observed over the uneven bottom east of the 100-fathom curve between the parallels of 43° 30′ and 44° 00′ N. The *Tampa* and the *Gripsholm* ran across the Labrador current to the north of the forty-fourth parallel. Neither they nor the patrol vessel sighted any ice on June 12.

On the 13th the patrol vessel steamed to the southwestward and finished searching the lower end of the Labrador current. When no ice was found it was felt pretty certain that the only berg south of 44° 30′ N. was the one found on the 11th near 43° N., 49° W. It was not seen near its previous location on the 13th because it had probably drifted to the southwest past the Tail by that time.

On the 14th, 15th, and 16th it was foggy or thick and stormy practically all of the time so no searching could be carried on. On the 17th the weather cleared. It was thought that the berg of the 11th had melted by this time. At any rate it was futile to waste valuable time trying to find this single small isolated berg after such a long separation. It was deemed more advantageous to search up the Labrador current as long as the visibility held good. Such a course was followed but no bergs were sighted in the area east and

northeast of the Tail on the afternoon of the 17th although a double lookout was posted aloft and much area was covered.

From the 13th to the 19th several weather reports by radio were sent each day to Cape Race for the benefit of the two planes waiting in Newfoundland for favorable conditions to cross the ocean. These reports gave not only the weather of the patrol vessel but also contained a compilation of late reports from a number of vessels strategically scattered over the ice-patrol area. Messages from the plane *Friendship* to Cape Race were intercepted on the afternoon of June 17 until about three hours after the plane had left Newfoundland for Europe.

Advantage was taken of continued good visibility on June 18 to search about 4,000 square miles of the Labrador current between 43° 20′ N. and 45° 30′ N. No ice was seen. Unfortunately five hours of dense fog on the following day prevented the search from being continued as far north as had been planned. By running at 80 to 85 revolutions per minute an area of about 3,500 square miles was searched on the 19th, however. This area lay between 45° 10′ N. and 46° 40′ N. and just west of the forty-eighth meridian. Again no ice was seen.

The *Modoc* spent the night of June 19 steaming across the Banks toward a rendezvous with the *Mojave*. That vessel was met and given the patrol duty at 11 a. m. on June 20 in approximately 45° 08′ N., 51° 39′ W.

No derelicts were seen, but one was twice reported during the sixth cruise. It was a schooner floating bottom up and was last reported on June 16 from 46° 31′ N., 55° 25′ W. Ten buoys, trees, and logs were reported to the patrol from in and near the ice-patrol area.

During the sixth cruise 15 oceanographic stations were taken, bringing the total for the season up to 95. During 122 hours, or 34 per cent of the time, visibility was less than two miles. Very moderate weather was experienced. It was only during the blow of the 15th and 16th that winds as strong as force 7 were observed. The wind blew with greater force than 5 during but 34 hours.

Continued surface warming of the sea was noted—38° water retreated north of the forty-eighth parallel during the sixth cruise as completely as 34° water retreated north of the same latitude during the fifth cruise. This effect undoubtedly made the ice disintegrate faster and faster in the higher latitudes. Only one berg was seen during the whole cruise and that one but for a short time on one day, so no great amount of first-hand information regarding disintegration could be accumulated.

The isotherms on the cruise chart are based on 1,147 observations from 131 vessels; 87 reports of ice were received during the 15-day cruise from 36 ship and shore stations, but during the last week the falling off was so great that only 16 ice reports were received

from 10 stations; 31 ships were furnished with special advice on request.

At the end of the cruise on June 20 it was estimated that about 27 bergs remained south of the forty-eighth parallel. Fully 22 of these were grounded on, or were very near to the Newfoundland coast and would never get anywhere near the United States-Europe tracks. The three bergs reported and the one sighted south of the Tail all undoubtedly melted before the cruise ended.

On June 20 it could be stated fairly definitely that there was no ice nearer the B tracks than 250 miles. To reach these tracks it would have to follow the Labrador current down along the eastern edge of the Banks and past the Tail, a distance of over 350 miles. At this season the time that would be consumed in traveling this distance should suffice to melt any ordinary berg that might hereafter have a tendency to drift south because of its favorable location in the axis of the Labrador Stream. The ice menace to the B tracks was believed definitely over for the season of 1928. The above conclusion was arrived at in a conference held on board the *Modoc* as soon as the *Mojave* was met on the morning of June 20.

THE SEVENTH CRUISE, "MOJAVE," JUNE 20 TO 23, 1928

The *Mojave* took over the oceanographic party and the ice-patrol duty at about 11 a. m. on June 20 in 45° 09′ N., 51° 40′ W. Nearly all the oceanographic gear on the *Modoc* was received at this time also, for further transfer to the *Marion* for use on a proposed cruise to Greenland waters.

Just after the relief was effected the commander, international ice patrol, sent a message to Coast Guard headquarters from the *Modoc* recommending the discontinuance of the 1928 patrol. Pending receipt of orders resulting from this message the *Mojave* undertook to search again along the eastern edge of the Grand Banks from 46° 45′ N. to 43° N.

By running at 100 revolutions per minute during all times of good visibility the second search within a week of this area was finished before dark on June 22. The limiting longitudes were 47° 00′ W. and 51° 30′ W. Again no ice was seen, but a band of water about 30 miles wide with surface temperatures from 39° to 41° F. was encountered until the patrol vessel had passed to the westward of the fifty-first meridian. Moderate weather prevailed and the only thing that hampered searching was the usual fog that was occasionally experienced in banks and patches.

At 6 p. m. on the 22d orders were received by radio from the *Modoc* at Halifax for the *Mojave* to discontinue the ice patrol and to return to Boston. Favored by easterly breezes at first, but hampered greatly

by fog later on, the *Mojave* finally arrived at the Boston Navy Yard on the afternoon of June 26, 1928.

The isotherm chart for the short seventh cruise was based on but 366 temperature observations sent in by 29 cooperating vessels. Only one ice report was received from south of the forty-eighth parallel. This was for a small berg reported in 46° 15′ N., 48° 17′ W. on June 21.

Vessels apparently commenced using the Belle Isle tracks on June 21, for 23 bergs and several growlers were reported to the patrol on that date from between Greenly Island and 52° 30′ N., 53° 00′ W.

Special information on request was sent to three vessels. No derelicts were heard of, and but one spar and one buoy were reported from within the patrol area. No oceanographic stations were taken.

Upon the discontinuance of patrol messages of thanks for efficient assistance were sent to the radio stations at Cape Race, Halifax, and St. Pierre. The final ice broadcasts were sent out on the evening of the 22d and on the morning of the 23d. They contained thanks to all cooperating ships for their indispensable assistance in the form of ice, water temperature, weather, and other reports.

Before leaving the patrol area, the following gratifying message was received from W. F. Berg, master of the *Vacoil*, "Realizing the hardships endured by the patrol, I wish to express my appreciation for your most valuable assistance to us during the past season." Before reaching Boston similar messages of appreciation were received from the *Majestic* and *Olympic*.

RADIO COMMUNICATIONS

In addition to being sister ships structurally the *Modoc* and the *Mojave* were equipped with identical radio apparatus for the ice-patrol work. Each vessel had one T–2 2-kilowatt tube transmitter, using either CW, ICW, or phone transmission; one T–4 200-watt tube transmitter using either CW or ICW, which replaced the 2-kilowatt spark set used during 1927; and a 500-watt XA crystal control high-frequency transmitter. The latter was similar to the one used during 1927 with some improvements and redesigning of the circuits used. The alterations were made by the United States Naval Research Laboratory for the Coast Guard, and served to make the set more efficient and consistent than before.

Direct communication with NAA, the United States naval radio station near Washington, D. C., was more successful than in any previous year. This traffic was all handled on high frequencies and the average distance between the ship and the shore station was approximately 1,350 sea miles.

The receiving apparatus on each ship consisted of a CGR–5 low-frequency receiver used for ship traffic and for communication with shore stations on intermediate and low frequencies. An RG receiver was used for high-frequency work, covering from 1,000 to 20,000 kilocycles. No real trouble was experienced with any of the radio apparatus. Kolster radio compasses were used to assist the vessels to find each other at relieving times. They would have been invaluable, also, had any assistance work been necessary during the season.

A splendid spirit of cooperation was noted on the part of the ship and shore stations in the vicinity of the patrol regions. There was an increase of over 17 per cent in the number of water-temperature and weather reports received from passing vessels over the 1927 season. A regular annual increase in all traffic seems to be the rule. An idea of the present volume can be gained by reading the tabulation on page 38 at the end of the summary report of the commander, international ice patrol.

The following schedule shows the times when regular routine traffic was handled. The times given are all Greenwich mean civil times and show the conditions at the beginning of the season. A few minor changes were made in the schedules with NBD, Bar Harbor, Me., during the progress of the patrol:

Time	Remarks
0000	Radio broadcast to shipping on 175 kilocycles.
0030	Report to Government observer, Washington, giving meteorological information.
0030	To Hydrographic, Washington, giving latest ice news.
0100	Schedule with Bar Harbor, Me.
0300	Receive from NAA, Washington, D. C., traffic on hand for ice patrol and receipt for traffic received via Bar Harbor.
1100	Radio broadcast to shipping on 425 kilocycles.
1200	Radio broadcast to shipping on 175 kilocycles.
1230	Report to Government observer, Washington, giving meteorological information.
1300	Schedule with Bar Harbor, Me.
2300	Radio broadcast to shipping on 425 kilocycles.

SUMMARY REPORT OF THE COMMANDER, INTERNATIONAL ICE PATROL

Commander W. H. Munter

The *Mojave* left Boston on March 20, 1928, to inaugurate international ice patrol. When 43° N., 52° W. was reached on March 24, the first patrol cruise was started. The *Modoc* divided evenly with the *Mojave* six full 15-day cruises. The patrol was discontinued at word received from Coast Guard headquarters on June 22, when the *Mojave* was on the third day of the seventh cruise.

Halifax, N. S., was used as a base for fuel and supplies as in previous seasons. During the season the two patrol vessels cruised a total of 18,083 miles, including the distance run in going to and from the base.

Weather during the whole time was remarkably moderate on the average. A few moderate gales, but no really severe ones, were experienced. Somewhat more than the usual amount of fog prevailed. The season was a very early one. The effect of this, combined with the mild winter preceding, was seen in the practical absence of field ice south of the forty-seventh parallel, in the unusually small amount of field ice reported by the Canadian ice patrol in the Gulf of St. Lawrence, in the general use of the Belle Isle tracks by the early date of June 21, and finally in the early recall of the international ice patrol vessels. The patrol's discontinuance on June 22 was earlier than in any year since 1920, when it ended on June 20.

While the total number of bergs that drifted south of 48° N. was greater than normal, less than half of the normal number of 51 bergs drifted south of the forty-third parallel. Early in the season many of the bergs came south well to the eastward of the Grand Banks and entered the Gulf Stream current south of Flemish Cap. They were then carried toward the northeast and melted clear of the B United States-Europe tracks but foul of the steamers on the C United States-Europe tracks between the forty-third and the forty-seventh meridians. There is grave danger under such conditions in adhering to the C tracks as late as was done this year.

During May the average position of the bergs was farther west in the Labrador current with the result that many of them were caught in the branch that flows along the eastern edge of the Grand Banks; some of these avoided being set onto the Banks or being curved off to the northeast. They are the ones that drifted south past the Tail of the Banks.

Towards the end of the season the bergs came down still farther west and most of them stopped in the slack water over the northern part of the Grand Banks or stranded along the Newfoundland coast between St. Johns and Cape Race. When the patrol was ended even these westerly bergs were thinning out rapidly, due in a large part, no doubt, to disintegration farther north. This would naturally be caused by summer solar warming of the air and sea surface water.

It was noted that a large pool of arctic and mixed water remained south of the Grand Banks right up to June 22. This was fed by a narrow but swift stream running along the eastern edge of the Grand Banks. A large proportion of the bergs that reached the pool via this stream was swung in a counterclockwise direction around it at speeds varying from 15 to 60 nautical miles per day. During the latter part of May and the first part of June six bergs went south of the forty-second parallel in this circulation. One of these on June 3 attained the unusual latitude of 38° 59′ N. in the longitude of 48° 51′ W. It had traveled rapidly across both the eastbound and westbound B United States-Europe tracks, then in effect, by running along one of the tongues of water radiating from the cold pool. Its most southerly position was due east of a point between Baltimore, Md., and Washington, D. C.

Ninety-five oceanographic stations were taken during the season. These were all worked out in accordance with the methods described in Bulletin No. 14, United States Coast Guard. The calculated currents usually agreed closely with the sets and drifts encountered and with the actual observed berg drifts. Because of the necessity for scouting for bergs during intervals of good visibility and also for following menacing bergs for long periods in the vicinity of the steamship lanes, the stations taken were usually just about where and when opportunity allowed. Had the patrol vessel been more free, their distribution in the patrol area would have been much better arranged.

One unusual feature of the bergs sighted this year was the amount of earth deposits in many of them. Some had layers of brownish gray matter streaked through them like icing between the layers of a cake. One was seen that had great irregular lines and patches of what looked like black soil embedded in one of its precipitous sides. It was impossible to obtain any dirt samples from the bergs. It is very difficult and dangerous to board a berg at sea. Only especially favorably shaped ones permit a footing to be obtained and then it is only during time of comparatively smooth sea that such bergs can be approached and landed on from small boats with any degree of safety.

Another unusual matter may prove of interest to ornithologists. Besides all the usual forms of bird life about the bergs and the Banks, this season snowy owls were seen on several of the icebergs. The owls,

if they had been present in former years, were either not observed or not recorded. These birds are native to the arctic regions only and are never seen so far south unless there is a shortage in their usual food supply in their regular haunts. The owls found inhabiting the bergs this season were supplied bountifully with the sea birds common to the regions comprising the Grand Banks.

The most vital thing in making the ice patrol of real value to shipping is radiotelegraphy. Here, as in previous years, the most gratifying cooperation was had from ship and shore stations. The communication personnel and apparatus of the ice patrol again proved equal to the task. Every effort should be continued to keep the radio material of the patrol vessels abreast with the progress of this most beneficial science. The magnitude and importance of the communication work of the patrol can be grasped in part by a study of the following figures:

Number of routine broadcasts transmitted	380
(At the height of the ice season these messages averaged about 300 words each.)	
Number of official messages to Washington	348
Ice and other information given to vessels on request	113
Water temperature and weather reports sent in by vessels	6, 534
Total number of vessels cooperating with the patrol	489
Number of ice and obstruction reports received by radio	644
Number of times medical treatment was given by radio	4
Violations of steamship track agreements reported	2
Total number of words transmitted and received by radio	450, 460

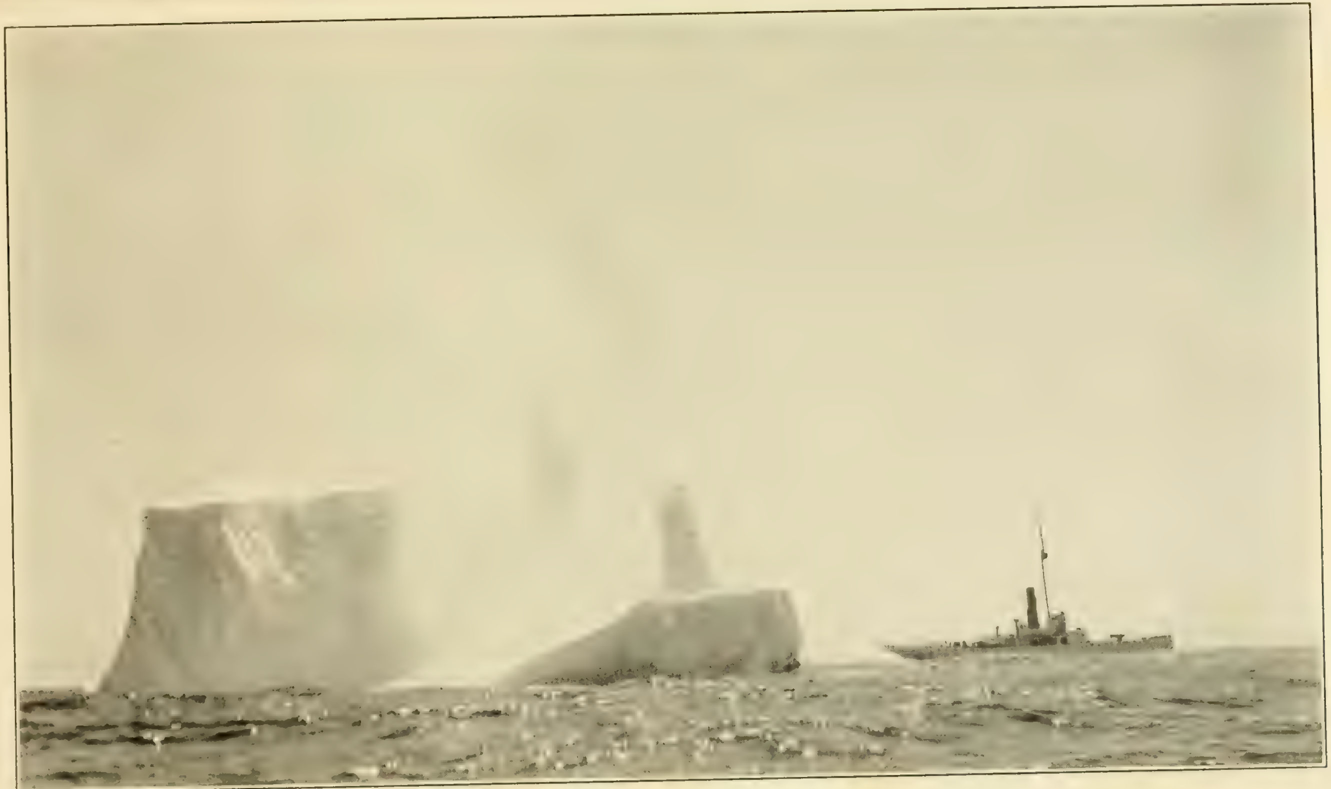

PLATE IV.—THE "MOJAVE" AND AN ICEBERG AS SEEN FROM A SHIP'S BOAT

PLATE V.—ICEBERG SEEN FROM THE "MODOC" MAY 17, 1928. THE TWO HIGH THIN WALLS APPEARED LIKE THE OUTER SIDES OF A FLOATING DRY DOCK

TABLE OF ICE AND OTHER OBSTRUCTIONS, 1928

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Feb. 9	1	Cape Race station	48 35	49 30	Field ice.
10	2	Frederick VIII	48 11 to 48 05	49 29 to 49 41	Small field ice.
11	3	Cape Race station	48 12 to 48 05	49 9 to 49 18	Light field ice.
12	4	do	48 25 to 48 11	49 18 to 49 13	Open drift ice.
12	5	Frederick VIII	45 10 to 45 03	59 45 to 60 15	Field ice.
12	6	Estonia	48 25 to 48 11	49 19 to 49 42	Open drift ice, same as 4.
12	7	do	47 45 to 46 36	51 27 to 53 01	Open drift ice.
13	8	do	45 01 to 44 53	60 42 to 61 23	Patches of drift ice.
15	9	Cape Race station	44 40 to 44 35	60 20 to 59 50	Open field ice.
18	10	do	45 00	59 00	Heavy field ice.
19	11	do	45 00	60 10	Do.
21	12	do	47 04 to 47 22	51 48 to 51 10	Patches of field ice.
22	13	Frederick VIII	47 06	49 00	Light field ice.
22	14	do	47 04 to 47 22	51 48 to 51 00	Light field ice, same as 12.
25	15	Cape Race station	47 46 to 48 24	50 23 to 48 57	Patches of field ice.
29	16	do	47 15 to 47 04	47 02 to 47 20	Heavy field ice.
29	17	do	47 25	47 05	Do.
29	18	do	47 03 to 46 45	47 53 to 47 20	Broken field ice.
29	19	Korsholm	47 25	47 20	Field ice.
Mar. 1	20	Cape Race station	47 53	47 05	Do.
1	21	do	46 55 to 46 50	47 10 to 47 35	Do.
1	22	do	44 38 to 44 38	60 00 to 60 20	Broken field and slab ice.
3	23	do	45 56 to 46 18	47 34 to 46 47	Fields of broken ice.
3	24	do	49 15	48 41	Field ice.
3	25	do	56 57	27 53	Large berg.
3	26	do	48 05 to 48 15	50 00 to 48 20	Heavy pan ice.
3	27	do	48 00	48 30	Field ice.
3	28	Kolsnaren	49 15 to 48 41	46 30 to 47 00	Ice field with bergs.
4	29	Cape Race station	48 26	47 30	Berg.
4	30	do	46 45	47 26	Field ice.
7	31	do	46 27	47 13	Broken field ice.
7	32	do	47 55 to 46 26	50 35 to 50 00	Field ice.
13	33	do	47 07	45 30	Small berg and growler.

Table of ice and other obstructions, 1928—Continued.

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Mar. 13	34	Cape Race station	44 57 to 45 31	60 55 to 58 07	Heavy and light field ice.
13	35	do	43 51	45 48	Lifeboat from S. S. Suevia.
14	36	do	44 03	54 35	Spar 30 feet long.
14	37	do	48 35	48 50	Berg.
14	38	do	48 35	48 50	Small bergs, same as 37.
14	39	do	46 50 to 46 27	47 36 to 47 02	Field ice.
15	40	Manatawny	46 21	47 34	Berg.
16	41	do	46 00	48 00	Field ice, small berg.
20	42	do	42 49	51 25	Spar 15 feet long.
21	43	do	46 15	47 45	Broken field ice.
22	44	do	48 37 to 48 10	49 11 to 50 20	2 small bergs, field ice, growlers.
26	45	Manchester Commerce	45 52	46 54	Low berg.
28	46	Nova Scotia	47 38	46 51	Growler.
28	47	Quaker City	48 05	48 05	Heavy field ice with small bergs.
29	48	M. Christensen	46 10	46 00	2 large bergs.
29	49	do	46 14	46 55	Field ice.
29	50	Ice patrol	44 59	48 39	Growler.
29	51	do	45 15	48 21	Berg and growler.
29	52	M. Christensen	45 42	47 37	Growlers.
29	53	do	45 45	47 55	Large berg.
29	54	do	45 27	48 25	Do.
30	55	Ice patrol	45 35	48 08	Berg, same as 53.
30	56	do	45 42	47 49	Berg.
30	57	do	45 36	47 49	Growler, same as 52.
30	58	do	45 39	47 38	Growler.
30	59	do	45 45	47 35	Berg.
31	60	do	45 08	48 21	Berg, same as 54.
31	61	do	45 14	48 22	2 growlers.
31	62	do	45 27	48 27	Growler.
31	63	do	44 56	48 40	Berg.
Apr. 1	64	do	44 42	48 23	Berg and 2 growlers, same as 63.
2	65	Kolsnaren	44 58	48 25	Berg, same as 53.
2	66	do	45 08	47 49	Berg and growlers.
2	67	Broompark	46 50	44 30	Small berg.
3	68	Estonia	47 28	46 58	2 bergs.
3	69	do	47 32	46 37	Berg.
3	70	do	47 44	46 21	Do.
3	71	do	47 37	46 04	Do.
3	72	do	47 52	46 11	Do.
3	73	do	47 52	46 07	Do.
3	74	Broompark	44 50	48 08	Do.
3	75	Karlshruhe	46 48	44 32	Do.
3	76	Broompark	44 38	48 40	Do.
3	77	Ice patrol	44 30	48 39	Growler.
3	78	do	44 37	48 41	Berg, same as 76.
3	79	do	44 53	48 07	Berg and 4 growlers, same as 74.
3	80	do	45 04	47 44	Berg.
4	81	do	45 07	47 16	Do.
5	82	Commandante Le Maille	45 00	46 45	Do.
5	83	Hellig Apaf	45 24	47 09	Do.
5	84	Bergensfjord	45 24	47 09	Berg, same as 83.
6	85	Innarenna	48 57	49 16	Field ice and growlers.
6	86	do	48 48 to 48 18	49 03 to 47 50	Small growlers.
6	87	Marguerite Finale	41 03	46 17	Drifting mine.
7	88	Innarenna	48 03	46 51	Large berg.
7	89	do	48 04	46 32	Berg.
7	90	do	47 54	46 31	Do.
7	91	John M. Connelly	39 29	53 31	Small black can buoy.
8	92	Stockholm	44 57	46 17	Large berg.
8	93	Manchester Citizen	45 00	46 24	Do.
8	94	do	44 53 to 44 52	46 17 to 46 27	Growlers.
9	95	Montrose	44 38	46 02	2 bergs.
9	96	Mexicano	44 22	46 05	Large berg.
10	97	Lituania	47 45 to 47 15	48 35 to 48 50	Heavy field ice.
10	98	do	47 40	48 40	Large berg.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north ° ′	Position: Longitude west ° ′	Nature of ice or obstruction
Apr. 10	99	Lithuania	47 08	47 52	Small berg.
10	100	do	47 15	47 48	Do.
10	101	Wytheville	44 58	46 35	Large.
10	102	Cranley	47 48	43 37	Medium.
10	103	New Amsterdam	44 21	45 12	Large berg.
10	104	Ice patrol	45 42	48 02	Do.
10	105	Cranley	47 49	43 50	Do.
10	106	Cairnvalona	47 40	43 45	Berg.
10	107	Ala	43 46	50 03	Log 4 feet diameter, 30 feet long.
10	108	Ice patrol	46 00	47 46	Large berg.
10	109	Andania	41 55	50 24	Large gas buoy painted red.
11	110	Gorm	47 00	45 10	Berg.
11	111	Arlington, Va	41 54	50 36	Bell buoy.
11	112	Oscar II	46 26	42 40	Small berg with calf.
11	113	Veendam	44 21	44 49	Berg, same as 103.
11	114	Greennack	47 25	44 45	Large berg.
11	115	do	47 28	44 30	Small berg.
11	116	do	47 51	43 30	Large berg.
11	117	do	47 53	43 20	Small berg.
11	118	Andania	44 21	44 20	Large berg.
11	119	Ice patrol	44 43	45 58	Do.
11	120	Cedric	44 20	44 25	Large berg, same as 118.
11	121	Cranley	46 46	46 40	Berg.
11	122	do	46 39	46 40	Do.
11	123	do	46 37	46 54	Do.
11	124	Topdalfjord	47 27	44 51	Large berg.
11	125	do	47 18	45 04	Berg.
11	126	do	47 13 to 47 22	45 09 to 45 20	Several growlers.
11	127	do	47 35	44 13	Berg.
11	128	do	47 17	44 38	Do.
12	129	Cameronia	44 30	43 46	Large berg, same as 118.
12	130	Topdalsfiord	46 02	48 17	Do.
12	131	do	45 48	47 24	Do.
12	132	Scythia	47 19	46 34	Medium berg.
12	133	do	47 09	46 48	Do.
12	134	Ice patrol	44 29	43 42	Berg and several growlers, same as 118.
12	135	do	44 26	43 45	Growler.
12	136	Scythia	46 58	46 59	Large berg.
12	137	do	47 02	47 06	Do.
12	138	do	46 59	47 14	Do.
12	139	do	46 57	47 18	Do.
12	140	Ice patrol	44 29	43 38	Growler.
12	141	Topdalsfjord	45 23	47 53	Berg.
12	142	do	45 18	48 06	Large berg.
13	143	Canadian Trapper	46 31	46 00	Berg.
13	144	Braheholm	44 15	43 24	Berg and several growlers, same as 118.
13	145	Ocean Prince	44 11	43 21	Berg, same as 118.
13	146	Canadian Trapper	47 02	44 49	Large berg.
14	147	Bellhaven	46 51	42 33	Berg and growler.
14	148	Nortonian	45 12	48 25	Small berg.
14	149	Bellhaven	46 37	43 38	Berg.
14	150	Nortonian	45 17	47 50	Do.
14	151	do	45 21	47 41	Large berg and several growlers.
14	152	Hada County	45 03	44 05	Berg.
14	153	Bellhaven	46 25	44 34	Large berg.
15	154	do	46 03	46 16	Medium berg.
15	155	do	45 46	47 20	Large berg.
15	156	do	45 49	47 27	Do.
15	157	do	45 38	48 09	Do.
15	158	Nova Scotian	46 37 to 46 22	46 41 to 47 51	9 bergs.
15	159	Nortonian	46 19	44 06	Large berg.
15	160	do	46 06	46 06	Small berg.
15	161	do	46 20	43 24	Growler.
15	162	Talisman	45 14	47 27	Berg.
15	163	do	45 28	47 22	Do.
15	164	do	45 18	47 53	Do.
15	165	do	45 20	48 02	Do.
15	166	Ice patrol	45 06	48 22	Two bergs.
15	167	Nova Scotia	47 00	45 09	Berg.
15	168	do	47 04	45 10	Growler.
15	169	Aggersund	47 00	49 00	Large berg.
15	170	Talisman	45 10	49 04	2 bergs.
16	171	Sisto	48 58	50 00	Big berg and growlers.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north °	′	Position: Longitude west °	′	Nature of ice or obstruction
Apr. 16	172	Ice patrol	44	59	49	02	2 bergs, 1 large and 1 small, same as 170.
16	173	do	45	06	48	51	Berg.
17	174	Emperor of Montreal	46	09	48	19	Large berg.
17	175	do	47	00	45	22	Do.
17	176	do	46	25	47	05	Do.
17	177	Ice patrol	45	01	48	46	Small berg, same as 157.
17	178	do	44	56	48	49	Berg.
17	179	Canadian Ranger	46	24	48	02	Do.
17	180	Sisto	48	48	49	56	Field ice extending West.
17	181	do	48	24	49	47	2 bergs, several growlers.
17	182	do	48	24	49	47	Patches field ice to southwest.
17	183	Ice patrol	44	53	48	31	Berg, same as 166.
17	184	do	44	52	49	10	2 bergs same as 172.
18	185	Carmia	46	42	47	52	Berg.
18	186	Berlin	43	43	48	45	2 bergs and 2 growlers.
18	187	Ice patrol	43	54	48	45	Berg.
18	188	do	43	48	48	44	Do.
19	189	Albertic	46	18	46	40	Do.
19	190	do	45	45	48	28	Do.
19	191	do	45	53	48	21	2 small bergs.
19	192	do	45	54	48	11	Berg.
19	193	do	45	54	48	06	Do.
19	194	Athenia	46	08	48	00	Large berg.
19	195	do	46	26	48	00	Do.
19	196	do	46	28	48	07	2 growlers.
19	197	do	46	40	48	07	Large berg.
19	198	Montclare	47	10	48	37	Large growler.
19	199	do	46	36	47	48	Large berg, same as 185.
19	200	Ice patrol	43	31	48	52	Berg.
19	201	Albertic	46	23	46	32	Small growler.
19	202	do	46	25	46	31	Large growler.
19	203	Ice patrol	43	16	49	14	Berg.
19	204	Stavangerfjord	46	49	47	45	Do.
19	205	do	46	29	47	46	Do.
19	206	Perseus	32	20	51	30	Floating mine.
19	207	Beaverburn	46	28	47	33	Berg.
19	208	do	46	17	47	44	Large berg.
19	209	Arabic	46	30	47	38	Berg, same as 207.
20	210	Montroyal	46	38	47	50	Large berg, same as 185.
20	211	do	46	27	47	50	Large low berg, same as 205.
21	212	Cape Race Station	41	56	53	18	Red cylindrical buoy.
21	213	Waban	40	57	48	00	Spar 14 inches diameter, floating upright.
21	214	Lituania	48	35	46	16	Large berg.
22	215	Gracia	43	09	49	17	Long low berg, same as 203.
22	216	Concordia	45	06	46	52	Large berg.
22	217	Cape Race Station	48	35	48	56	Berg and growler.
22	218	Concordia	45	06	48	29	Berg.
22	219	Majestic	40	16	63	29	Black spherical gas buoy, unlit.
23	220	Asta	49	25	49	30	Large berg.
23	221	do	49	00	50	00	4 low large bergs.
23	222	Knockfierna	48	08	46	28	Berg and growler.
23	223	do	47	06	47	17	Berg.
23	224	do	47	16	47	22	Do.
23	225	Federal	33	40	42	22	Stump of mast projecting 6 feet out of water.
23	226	Kentucky	46	18	46	42	Large berg.
23	227	Ice patrol	42	45	49	10	Low berg, same as 203.
23	228	Adour	47	00	40	57	Berg.
24	229	Cairnvalon	45	14	48	09	Large berg.
24	230	do	45	22	48	00	Do.
24	231	do	45	30	48	04	Berg.
24	232	do	45	42	47	46	Do.
24	233	Cairnglen	47	36	46	01	Large berg.
24	234	do	47	28	46	26	Small berg.
24	235	do	47	23	46	37	Large berg.
24	236	do	47	22	46	39	Growler.
25	237	Winona County	42	35	45	25	Black and white bell buoy.
26	238	Cairndhu	48	33	46	20	Berg.
27	239	do	48	19	47	10	Large low berg.
27	240	Manchester Citizen	46	25	47	07	Low berg.
27	241	Dresden	47	30	46	01	Do.
27	242	do	47	26	46	01	Berg and growler.
27	243	do	47	26	46	16	Berg.
27	244	do	47	10	46	38	Do.
27	245	do	47	17	46	39	Small berg.
27	246	Ice patrol	42	50	50	10	Berg, same as 203.
27	247	Beaverlake	46	52	47	11	Long low berg.
27	248	Montnairn	47	11	47	21	Large berg; numerous growlers.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
Apr. 27	249	Hjelmaren	45	08	47	58	Berg.
28	250	Malmen	43	36	56	46	Heavy round timber, sticking 3 feet out of water.
28	251	Canadian Rancher	47	16	46	05	Large berg.
29	252	Cape Race station	47	03	46	49	Small berg.
29	253	do	47	07	46	52	Do.
29	254	do	47	00	46	57	Growler.
29	255	do	46	50	47	05	Low berg, same as 247.
29	256	Laval County	45	30	48	17	3 growlers.
29	257	do	45	22	48	34	Large berg.
29	258	Metagama	47	15	45	27	Long low berg.
29	259	do	47	04	45	51	Berg.
29	260	do	46	53	46	35	Growler.
29	261	do	46	53	46	40	Do.
29	262	do	46	49	46	51	Do.
29	263	do	46	48	47	00	Long low berg.
29	264	Montroyal	46	10	46	52	Low lying berg.
29	265	do	46	22	46	02	Berg.
29	266	Humber Arm	48	12	47	30	3 large bergs.
29	267	Manchester Civilian	48	00	45	53	Berg.
29	268	do	47	52	46	23	Berg and growlers.
30	269	Torne	44	14	48	20	Large berg.
30	270	Sergent Gouarre	44	54	48	52	Berg.
May 1	271	Trevose	34	42	45	45	Large buoy heavily barnacled.
1	272	Beaverbrae	47	22	44	47	Small berg.
1	273	America	40	44	49	10	Large white round top buoy marked "CABE."
2	274	Cape Race station	48	48	50	35	Large low berg.
2	275	do	47	20	46	21	Small berg.
2	276	Calgaric	47	16	46	08	Large berg.
2	277	Alaunia	47	15	44	30	Small berg, same as 272.
2	278	Alexander	47	22	45	42	Berg and growlers.
2	279	Alaunia	47	10	45	35	2 bergs.
3	280	Montcalm	47	20	46	38	Large berg.
3	281	do	47	35	46	07	Large berg and several growlers.
3	282	Andania	47	47	45	57	Large berg.
3	283	Cairnross	47	19	44	23	Small berg.
4	284	do	46	43	46	42	Low lying berg.
4	285	Cameronia	48	25	43	59	Small berg and growlers.
4	286	Melita	46	42	46	08	Small berg.
4	287	Artigas	43	02	50	40	Large berg, same as 203.
4	288	Lord Downshire	47	15	46	39	Large berg and growlers.
4	289	do	47	16	46	55	Low berg and growlers.
5	290	Aurania	46	26	45	25	Growler.
3	291	West Kedron	39	29	64	23	Gas and whistling buoy painted red.
5	292	Point Breeze	44	55	47	15	Berg.
5	293	Cape Race station	47 37 to 47	34	60 00 to 59	40	Field ice to northward.
6	294	Paris	42	39	44	58	Log about 50 feet long.
6	295	Tynebridge	42	27	50	02	Large berg.
7	296	Cape Race station	47	59	52	17	Do.
7	297	do	48	12	51	40	Do.
7	298	do	48	07	51	44	2 growlers.
7	299	Blairatholl	47	34	48	46	Growler.
7	300	do	47	37	48	50	Small berg.
7	301	do	48	12	47	36	Small berg, several growlers.
7	302	Balsam	42	37	48	51	Large berg.
7	303	Ice patrol	42	22	49	53	Berg.
7	304	do	42	13	50	13	Small berg, same as 295.
7	305	Blairatholl	47	10	49	35	Large berg.
8	306	Newfoundland	47	59	50	37	5 growlers.
8	307	do	48	10	50	20	Growler.
8	308	Beaverdale	46	12	44	55	Small berg.
8	309	Cape Race station	47	48	48	34	Large growler.
8	310	do	47	35	49	42	Small berg, many growlers.
8	311	do	47	34	49	46	Very large berg.
8	312	do	47	29	49	27	Berg.
8	313	do	47	21	49	50	Do.
8	314	do	48	28	50	00	Do.
8	315	Newfoundland	48	22	49	48	Large and small berg, scattered growlers.
8	316	Regina	47	10	46	47	Large berg.
8	317	Colytto	46	13	46	36	Berg.
8	318	do	46	08	46	55	Large berg.
8	319	California	46	42	48	49	Do.
8	320	do	46	41	48	40	Small berg.
8	321	do	46	40	48	20	2 growlers.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 8	322	California	46 43	48 22	Growler.
9	323	Ice patrol	42 08	50 10	Small berg, same as 295.
9	324	do	42 10	50 00	Small berg, same as 303.
9	325	Bochum	46 17	47 16	Do.
9	326	California	47 02	47 40	Large berg.
9	327	Metagama	46 02	47 25	Large berg with growlers.
9	328	do	46 11	47 08	Growler.
9	329	Cape Race station	47 37	51 07	Berg.
9	330	do	47 56	50 58	Very large, low berg.
9	331	do	48 00	50 33	Growler.
9	332	do	48 13	50 21	Large berg.
9	333	do	48 02	50 29	Small berg and growler.
9	334	Drakepool	45 56	47 27	Berg.
9	335	Bochum	46 16	46 47	Do.
9	336	Bridgepool	44 38	46 16	Do.
9	337	Cape Race station	48 35	50 00	Small berg and growler.
9	338	do	48 12 to 47 53	50 44 to 51 55	12 bergs, several growlers.
9	339	Africa	47 46	48 25	Berg.
9	340	do	47 56	48 38	Small berg.
9	341	Doric	47 39	54 17	Large berg.
9	342	do	48 02	41 40	Do.
9	343	do	48 07	51 44	2 growlers.
9	344	do	47 34	48 46	Growlers, same as 299.
9	345	do	47 37	48 50	Small berg, same as 300.
9	346	do	48 12	47 36	Small berg, several growlers, same as 301.
9	347	Bridgepool	44 35	48 28	Large, low berg.
10	348	Canadian Aviator	47 40	48 17	Very large berg, same as 339.
10	349	do	47 20	50 10	12 bergs.
10	350	Beaverhill	47 40 to 47 00	48 35 to 45 40	Medium berg.
10	351	Minnedosa	47 12	47 07	Low-lying berg.
10	352	Pennland	47 14	46 40	Large berg.
10	353	Ansonia	46 57	46 48	Berg.
10	354	do	46 51	47 22	Large low berg.
10	355	do	46 39	47 28	Large berg, several growlers.
9	356	Cape Race station	47 52	51 56	Large bergs, several growlers in radius of 10 miles.
9	357	do	47 12	50 05	Bergs.
9	358	do	47 29	50 08	Do.
9	359	do	47 24	50 05	Do.
9	360	do	47 56 to 48 10	52 00 to 51 40	8 bergs, several growlers.
10	361	Doric	47 00	48 12	Growler.
10	362	do	46 50	48 15	Do.
10	363	do	46 48	48 35	Berg.
10	364	do	46 50	48 37	Large berg.
10	365	Concordia	46 00	47 35	Berg.
10	366	Baunach	42 06	50 08	Berg, same as 295.
10	367	do	42 02	50 08	Berg, same as 303.
10	368	Ansonia	46 40	48 10	Growler.
10	369	do	46 22	48 38	Berg.
10	370	Pennland	46 50	47 16	Berg and growlers.
10	371	do	47 18	48 00	Growler.
10	372	Bolingbroke	51 33	35 22	Heavy spar floating upright, wreckage attached.
10	373	Concordia	46 22	47 23	Small berg.
10	374	do	46 14	46 40	2 small bergs.
10	375	Bannock	42 31	48 56	Berg, same as 302.
10	376	Albertic	46 44	47 54	Large berg.
10	377	do	46 38	48 03	Do.
10	378	do	46 37	48 00	Small berg.
10	379	Concordia	46 21	46 08	Growler.
10	380	do	46 34	45 48	Small berg.
10	381	Bergenfjord	47 18	47 59	Growler, same as 371.
10	382	do	47 14	48 26	2 large bergs.
10	383	do	46 53	48 35	Large growler.
10	384	do	47 00	48 36	Berg.
10	385	Athenia	48 16	48 53	Do.
10	386	do	48 12	49 51	Growler.
10	387	do	48 04	50 03	Do.
10	388	do	48 00	50 07	Do.
10	389	do	48 08	50 07	Berg.
10	390	do	48 05	50 07	2 growlers.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north °	Position: Latitude north ′	Position: Longitude west °	Position: Longitude west ′	Nature of ice or obstruction
May 10	391	Athenia	47	38	50	55	Growler.
11	392	Bolingbroke	48	02	45	10	Low lying berg.
11	393	Trocas	35	47	53	26	Conical whistle buoy.
11	394	Cape Race station	48	35	51	37	2 bergs.
12	395	Nova Scotia	47	15	52	38	Large berg.
12	396	Cape Race station	47	44	52	41	3 small bergs.
13	397	City of Florence	41	36	46	14	Floating wreckage projecting 4 feet.
14	398	Cape Race station	47	20	49	48	Berg.
15	399	Novara	48	03	51	38	Large berg, several growlers.
15	400	Alaunia	45	54	48	30	Do.
15	401	Andania	47	01	46	43	Do.
16	402	Cameronia	46	51	47	22	Do.
16	403	Limerick	41	01	53	02	Large log, about 15 feet long.
17	404	Somerstadt	40	19	47	51	Small growler..
17	405	Yorck	43	34	49	06	Large berg.
17	406	do	43	38	48	56	Do.
17	407	Terre Neuve	45	40	46	02	Berg.
17	408	Tricolor	43	43	43	43	Spar 60 feet long.
17	409	Cape Race Station	48	05	51	41	Large berg.
17	410	Vollrath Tham	46	09	48	41	Berg.
18	411	Coracero	48	00	48	57	Do.
18	412	do	47	54	49	44	Large low berg.
18	413	do	47	41	49	43	Large berg.
18	414	do	47	44	49	46	Growler.
18	415	do	47	47	49	50	Berg.
18	416	do	47	44	49	54	Growler.
18	417	Ice patrol	44	05	49	13	Berg.
18	418	Cape Race station	47	54	49	37	Growler.
18	419	do	47	55	49	30	Large berg.
18	420	do	47	52	49	30	Growlers.
18	421	Cora Sero	47	33	50	42	Do.
18	422	Bristol City	42	01	45	37	Heavy spar floating upright, 3 feet showing above water.
18	423	Baron Carnegie	46	49	47	36	Berg.
18	424	do	46	51	47	34	Growler.
18	425	do	46	05	47	50	Large berg.
18	426	Hagen	47	53	48	50	Large low berg.
18	427	Cape Race station	47	23	50	38	Low lying berg.
18	428	do	48	46	49	25	Berg.
18	429	do	48	45	48	45	Do.
18	430	do	47	53	52	48	Large berg.
18	431	do	47	41	52	30	Bergs.
18	432	do	48	50	48	32	Do.
18	433	do	48	10	49	20	Growler.
18	434	do	48	15	49	43	Berg.
18	435	do	48	08	49	55	Growler.
19	436	Bourdonnais	42	30	44	46	Log 30 feet long, covered with marine growth.
19	437	Kearney	43	23	53	45	Log 30 feet long, 2 feet diameter.
20	438	Minnedosa	47	42	50	08	Berg.
21	439	Ice patrol	42	42	50	25	Berg, same as 405.
21	440	do	42	45	49	55	Large berg, same as 406.
21	441	do	42	40	50	17	Several growlers.
21	442	Cape Race station	48	11	50	43	Small berg.
22	443	Montroyal	47	47	49	36	Large berg.
22	444	Sarcoxie	42	25	49	38	Berg.
22	445	Beaverhill	47	05	50	43	Large berg.
22	446	Montroyal	47	23	50	30	Berg.
22	447	do	47	40	49	51	4 small growlers.
22	448	do	47	40	50	13	Large berg.
22	449	do	47	31	50	18	Do.
22	450	do	47	21	51	14	Do.
22	451	Doric	47	46	49	51	3 growlers, same as 447.
22	452	Cape Race station	47	40	52	53	One large; several small bergs.
23	453	Demetrios M. Diacakis	43	08	49	38	Berg.
23	454	Ampetco	39	29	55	58	Gas and whistling buoy, painted red.
23	455	Lord Dounshire	47	35	50	07	Berg.
23	456	Swainby	41	54	48	57	Black can buoy, covered with marine growth.
23	457	Cape Race station	47	40	50	08	Berg.
23	458	do	47	23	51	21	Growler.
24	459	Aurania	47	14	50	32	Small berg with growler.
23	460	Hybert	38	03	50	50	Large gas buoy, painted black.
24	461	Regina	47	13	51	39	Berg.
24	462	do	47	18	51	37	Growler.
24	463	do	47	09	51	56	Do.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position				Nature of ice or obstruction
			Latitude north		Longitude west		
			°	′	°	′	
May 24	464	California	47	01	52	01	Berg and growler.
24	465	Clara Camus	47	10	51	02	Small berg.
24	466	Aurania	47	15	50	55	Berg.
24	467	do	47	00	51	59	Growler.
24	468	Letitia	47	06	51	19	Berg.
24	469	California	47	06	51	43	Do.
24	470	Megantic	47	53	48	32	Do.
24	471	do	47	38	49	34	Do.
24	472	Letitia	47	12	51	50	Do.
24	473	do	47	10	51	52	Growler.
24	474	do	47	04	52	01	Berg.
24	475	do	47	02	52	03	Growler.
25	476	Bolivian	45	34	48	41	Berg.
25	477	Arabic	47	24	50	44	Small berg.
25	478	Bolivian	45	10	50	18	Do.
25	479	Letitia	47	28	50	35	Berg.
25	480	do	47	14	51	03	Do.
24	481	Cape Race station	47	27	50	05	Large berg.
25	482	President Garfield	40	53	55	39	Red cage whistling buoy.
25	483	Ice patrol	42	10	50	46	Berg, same as 406.
26	484	Pajala	48	08	52	14	Large berg.
26	485	Norefjord	47	05	52	02	Do.
26	486	Caledonian	41	38	49	00	Berg.
27	487	The Lambs	40	38	44	20	Log 2 feet diameter, 30 feet long.
27	488	Cape Race station	47	35	52	38	5 growlers in vicinity between Motion Head and Bull Head, 3½ miles offshore.
27	489	Causasier	42	04	49	28	Large berg.
26	490	Cape Race station	46	24	53	05	Do.
27	491	Oswal	42	03	49	17	Do.
28	492	Beaverford	46	41	51	54	Berg.
28	493	Fantoise	41	10	45	56	Floating mine with several horns.
28	494	France	41	18	48	23	Berg, 150 feet long, 18 feet high.
28	495	Federal	40	00	52	56	Large buoy with red superstructure.
28	496	Ice patrol	41	50	49	18	Berg, same as 406.
29	497	Calgaric	46	30	52	47	Small berg.
29	498	do	46	38	51	59	Do.
29	499	Elisebeth Maersk	40	20	62	42	Wreck of masthead 10 feet above water.
29	500	Cape Race station	47	30	52	30	Large low berg.
28	501	do	46	52	52	40	Berg.
28	502	do	47	00	51	23	Do.
28	503	do	47	04	51	26	Do.
28	504	do	47	11	50	56	Do.
28	505	do	46	32	52	42	Small berg and growler.
28	506	do	46	34	52	56	3 growlers.
29	507	Montroyal	47	00	50	01	Large berg.
29	508	Transylvania	46	25	52	56	Berg and numerous growlers.
29	509	Val Fiorita	45	36	48	31	Berg and several growlers.
29	510	Calgaric	46	50	51	36	Small berg.
29	511	do	46	51	51	33	Do.
29	512	do	47	06	50	58	Berg and 2 growlers.
29	513	Transylvania	46	43	52	05	Berg and growler.
29	514	do	46	51	51	43	Small berg.
29	515	do	46	52	51	40	Do.
29	516	do	47	21	49	54	Large berg.
29	517	Yorkmoor	45	48	48	43	Berg.
29	518	do	45	47	48	26	Berg and growlers.
29	519	Transylvania	47	06	51	02	Large berg.
30	520	Christian	41	10	48	17	Berg and growler, same as 406.
30	521	Ice patrol	41	08	47	58	Berg and growlers, same as 406
30	522	do	41	12	47	57	Growler, same as 406.
29	523	Cape Race station	46	13	53	33	Do.
30	524	do	46	16	53	05	Small berg.
30	525	do	46	46	51	46	Do.
30	526	do	46	57	51	05	Large berg.
30	527	do	46	47	51	40	Small berg.
31	528	Duivendrecht	40	56	48	51	Berg.
31	529	Hallmoor	40	47	48	54	Low berg.
31	530	Ice patrol	41	13	46	53	Berg, same as 406.
31	531	do	41	18	46	53	Large growler, same as 406.
31	532	Suffren	40	39	48	52	Large berg, same as 529.
June 1	533	American Trader	40	26	49	14	Small berg, same as 529.
1	534	Ice patrol	42	02	46	22	Numerous growlers, same as 406.
1	535	Montcalm	46	42	52	43	Large berg.
1	536	Empress of France	46	59	51	44	Berg.
1	537	Andania	46	47	52	35	Do.
1	538	Ice patrol	42	10	46	28	Berg and growlers, same as 406.
2	539	Empress of France	46	59	51	34	Berg.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
June 2	540	Oak park	39	57	49	52	Berg, same as 529.
2	541	Ice patrol	42	38	46	20	Berg, same as 406.
2	542	Beaverwyk	41	52	49	41	Small berg and growlers.
2	543	Ariano	46	42	51	52	Do.
2	544	do	46	56	51	12	2 growlers.
2	545	Cape Race station	47	00	51	35	Small berg.
2	546	do	47	05	51	25	Growler.
2	547	Antonio Lopez	39	39	50	00	Berg, same as 529.
2	548	Simonburn	42	03	43	55	Red bell buoy with black superstructure
2	549	Baunack	45	32	48	45	Large berg.
2	550	Bochum	48	32	50	51	Do.
2	551	Afrika	46	10	48	44	2 bergs—1 large, 1 small.
2	552	Canadian Conqueror	47	29	50	05	Large berg.
2	553	Ice patrol	43	04	46	17	Berg, same as 406.
2	554	Convallari	47	04	51	08	Large berg.
2	555	Bochum	46	49	52	31	Cone-shaped berg.
2	556	do	46	48	52	38	Growler.
3	557	Megantic	47	15	49	50	Berg.
2	558	Cape Race station	46	42	51	52	Small berg, same as 543.
2	559	do	46	56	51	12	2 growlers, same as 544.
2	560	do	46	58	52	52	Berg.
2	561	do	47	08	52	50	Do.
2	562	do	47	37	52	37	Low berg
2	563	do	47	59	50	05	Berg.
2	564	do	48	45	51	04	Low berg.
2	565	do	48	24	51	40	Berg.
3	566	Vredenburg	46	52	52	30	Large berg.
3	567	Yokohama	39	11	48	54	Small berg, same as 529.
3	568	Goldmouth	38	59	48	57	Small berg, same as 567.
3	569	Hanover	39	01	48	34	Do.
3	570	Dresden	40	28	50	00	Gas and whistling buoy painted red.
3	571	Ivar	47	32	49	50	2 growlers.
3	572	Port Dowen	42	43	43	25	Log 30 feet long covered with marine growth.
4	573	Majestic	40	18	61	30	Do.
4	574	Port Bowen	40	30	46	28	Large red buoy or mine.
4	575	Letitia	47	10	51	23	Berg.
4	576	do	47	15	50	57	Do.
4	577	Melita	47	16	50	50	Small berg.
4	578	Jacques Cartier	40	13	47	11	Barnacled log 60 feet long.
4	579	Melita	47	47	49	58	Large low berg.
4	580	Letitia	47	35	49	51	Berg.
4	581	Cape Race station	46	54	52	23	Do.
4	582	do	46	58	52	19	Do.
4	583	do	47	12	49	31	Do.
4	584	do	47	55	52	39	Do.
4	585	do	47	31	52	28	Large flat berg ¾ mile long, many growlers.
4	586	do	48	26	52	20	Berg.
4	587	do	48	48	52	27	Do.
4	588	do	48	49	49	48	Large growler.
4	589	do	46 40 to 47	40	52 40 to 52	30	Several bergs aground near coast.
5	590	Tractor	46	25	48	21	Berg and growlers.
5	591	Regina	47	13	50	52	Berg.
5	592	Tiger	48	33	50	26	Small berg.
5	593	Regina	47	39	49	47	Berg.
5	594	Esk Bridge	42	32	48	50	Do.
5	595	Texas	48	34	49	18	Small berg and growler.
5	596	Vomeria	40	57	52	07	Gas and whistle buoy.
5	597	Sydland	47	35	49	48	Berg, same as 593.
5	598	do	47	15	49	48	Low flat berg.
5	599	New York	41	25	48	31	2 large bergs.
6	600	California	47	22	51	00	Berg.
6	601	do	47	19	50	46	Do.
6	602	Narvik	48	35	49	56	2 large bergs.
6	603	Schleswig	46	15	52	14	Berg and growlers.
6	604	California	47	33	49	38	Berg.
7	605	Caledonia	47	26	50	56	Do.
6	606	Cape Race station	48	55	50	10	Large berg.
6	607	do	47	24	49	25	Berg.
6	608	do	47	36	49	35	Berg, same as 604.
6	609	do	48	05	51	08	Large berg and several growlers.
6	610	Athenia	47	35	49	34	Berg, same as 604.
6	611	do	47	23	50	49	Do.
6	612	do	47	30	51	00	Berg, same as 605.
7	613	Doric	47	16	50	58	Berg.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
June 7	614	Cape Race station	47	21	49	28	Berg, same as 607.
7	615	do	47	31	49	38	Berg, same as 604.
7	616	Fishpool	46	45	47	57	1 large and 2 small bergs.
7	617	do	46	48	47	45	Small berg.
7	618	Chifuku Maru	40	38	48	14	Log 20 feet long 2-foot diameter.
7	619	do	40	38	48	17	Small red buoy.
7	620	Beaverbrae	47	20	50	39	Berg.
7	621	do	47	21	49	28	Berg, same as 607.
7	622	do	47	31	49	38	Berg, same as 604.
7	623	Doric	47	05	52	12	Berg and growlers.
8	624	Teiresias	41	33	46	20	Large round rusty buoy, marked "Dangerous".
7	625	Cape Race station	42	28	44	24	Bell buoy.
7	626	do	48	33	51	08	Large berg.
8	627	do	47	28	49	26	Berg.
8	628	do	47	27	50	50	Do.
8	629	do	47	24	51	20	Berg, same as 605.
8	630	do	48	09	48	09	Berg.
8	631	Albertic	47	26	49	30	Berg, same as 627.
8	632	Cape Race station	48	26	51	10	Berg, same as 626.
8	633	do	47	26	49	30	Berg and growlers, same as 627.
8	634	do	47	05	52	19	Large berg.
8	635	do	47	29	49	35	Berg and 2 growlers, same as 604.
8	636	do	47	13	50	44	Berg, same as 601.
8	637	do	47	16	50	57	Berg, same as 600.
9	638	Comino	47	51	47	46	Small berg.
9	639	Rudby	47	06	52	19	Large berg, same as 634.
9	640	do	47	06	52	46	2 bergs, 1 large and flat.
9	641	do	46	54	52	52	Large berg.
10	642	Peursum	45	30	54	40	Log projecting 4 feet above water.
10	643	Canadian Inventor	47	21	48	38	Large berg.
11	644	Montcalm	47	12	51	06	Do.
11	645	do	47	12	51	10	Small low berg.
11	646	Ice Patrol	43	04	49	00	Berg and growler.
11	647	Andania	47	18	51	03	Berg.
11	648	Peursum	47	06	52	32	Large berg.
11	649	do	47	08	52	29	22 growlers.
11	650	do	48	20	52	49	Berg.
12	651	Manstpool	47	16	49	51	Small berg.
12	652	Cape Race station	44	32	51	12	Gas and whistling buoy.
12	653	do	46	22	55	47	Capsized schooner projecting 20 feet, hull painted black, rigging afloat.
12	654	Cameronia	47	14	51	08	Small berg, same as 645.
12	655	do	47	22	51	05	Berg.
12	656	Beaver Dale	47	29	49	37	Do.
12	657	Olendam	39	23	49	21	Large gas and whistling buoy.
12	658	Cape Race station	47	22	50	52	Berg.
12	659	do	47	42	52	05	Small berg.
13	660	Crefeld	47	11	52	23	Berg.
13	661	Cape Race station	48	23	51	28	Do.
13	662	Cuba	39	47	48	39	Large gas and whistling buoy.
13	663	Casper	48	20	50	13	Berg.
14	664	Lapland	47	36	49	34	Low-lying berg.
14	665	American Farmer	44	31	48	38	Tree 40 feet long with branches attached.
15	666	Caledonia	42	17	43	43	Bell buoy rusty and covered with marine growth.
15	667	Brant County	47	58	50	51	Small berg.
16	668	Byron	40	41	59	32	Mast projecting 15 feet.
16	669	Cape Race station	47	20	51	25	Large berg.
16	670	do	47	33	52	41	Berg in fresh water.
16	671	do	47	00	52	53	12 bergs grounded; growlers floating off from berg.
16	672	do	46	25	55	25	Large dead whale.
16	673	do	46	31	55	25	Capsized schooner rigging afloat hull painted black projecting 20 feet.
16	674	do	48	07	52	35	Growlers.
17	675	Albertic	47	16	51	00	Large berg.
17	676	Cape Race station	47	22	51	10	Do.
18	677	Bochum	48	05	50	12	Berg, same as 663.
17	678	Cape Race station	41	27	56	34	Red conical buoy.
18	679	do	41	57	54	26	Buoy marked, cable painted white, small flags flying.
18	680	do	47 35 to 46	45	52 30 to 52	50	Several bergs and growlers.
19	681	Wearpool	47	20	49	35	4 growlers.

Table of ice and other obstructions, 1928—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
June 20	682	Kolsnaren	47	22	50	59	Berg.
20	683	Caledonia	47	13	50	41	Small berg.
21	684	Regina	52	28	53	28	Long low berg and growler.
21	685	do	52	22	53	44	Small berg.
21	686	Melita	52	32	53	09	2 growlers.
21	687	do	52	15	53	22	2 bergs.
21	688	do	52	21	53	28	Large low berg.
21	689	do	52	10	53	45	3 bergs.
21	690	do	52	20	53	50	2 large bergs.
21	691	Aurania	52	03	54	44	Large berg.
21	692	do	51	57	54	51	Do.
21	693	do	51	56	54	57	Do.
21	694	Markland	38	12	44	47	Rusty gas and whistling buoy, whistle working.
21	695	Minnequa	42	33	44	41	Floating spar 60 feet long.
21	696	Emma Maersk	40	11	46	37	Conical white and red buoy.
21	697	Stockholm	46	15	48	17	Small berg.
21	698	California	51 to 51	53 to 22	56 to 57	00 to 10	9 bergs along shore.
21	699	do	51 to 51	46 to 15	55 to 5	58 to 05	4 bergs, several small pieces.

WEATHER

This section gathers together certain meteorological facts observed on the ice-patrol vessels during the 1928 ice season. The conditions can be taken as those that prevailed at 43° N., 50° W., for all practical purposes, but too great stress should not be placed on this position, for the patrol ships cruised from 46° 50′ N. to 40° 40′ N. and from 53° 00′ W. to 43° 20′ W. There were areas of cold surface water and of warm surface water in the patrol area which had consequent marked effects on local weather, especially with respect to fog and surface air temperatures. It was noted that the air temperatures followed the values of the sea temperatures closely and quickly most of the time wherever the patrol vessels went.

The weather diagrams for each month give at a glance the wind directions and forces averaged for every 12 hours, the barometric curve, and the time and duration of fog and low visibility. This year maximum and minimum and average surface air temperatures are given for each month. The scientific value of these temperatures is mitigated by the above noted mobility of the observing stations and by the fact that ordinary poorly exposed ship's air thermometers were used in making the observations. It is believed that the values will be of interest, however, in showing about what temperatures should be expected and prepared for on ice patrol. The average air temperatures were obtained roughly by adding all the daily maxima to all the daily minima and dividing the sum by twice the number of days.

MARCH

Maximum air temperature, 50° F.

Minimum air temperature, 28° F.

Average air temperature, 37.8° F.

Visibility was less than 4 miles 57 per cent of time.

Visibility was less than 2 miles 34 per cent of time.

The ice patrol was in effect during only the last 10 days of March. The percentage of bad visibility was extremely high for early in the season. There were three days of dense fog from the 25th to the 28th caused by Southwest winds blowing, as in summer, over the cold water. They were apparently caused by the atmospheric circulation set up between a High over the ocean to the south and a Low situated over the northeastern part of North America.

Only two cyclones affected the barometer on the patrol vessel to a marked degree. The one whose center passed just to the south on

the night of March 23 gave a few hours of moderate gales from the Northwest on the 24th. These were the only gales of the month, for the storm of the 31st did not produce anything stronger than a fresh breeze In general the weather was very moderate for March.

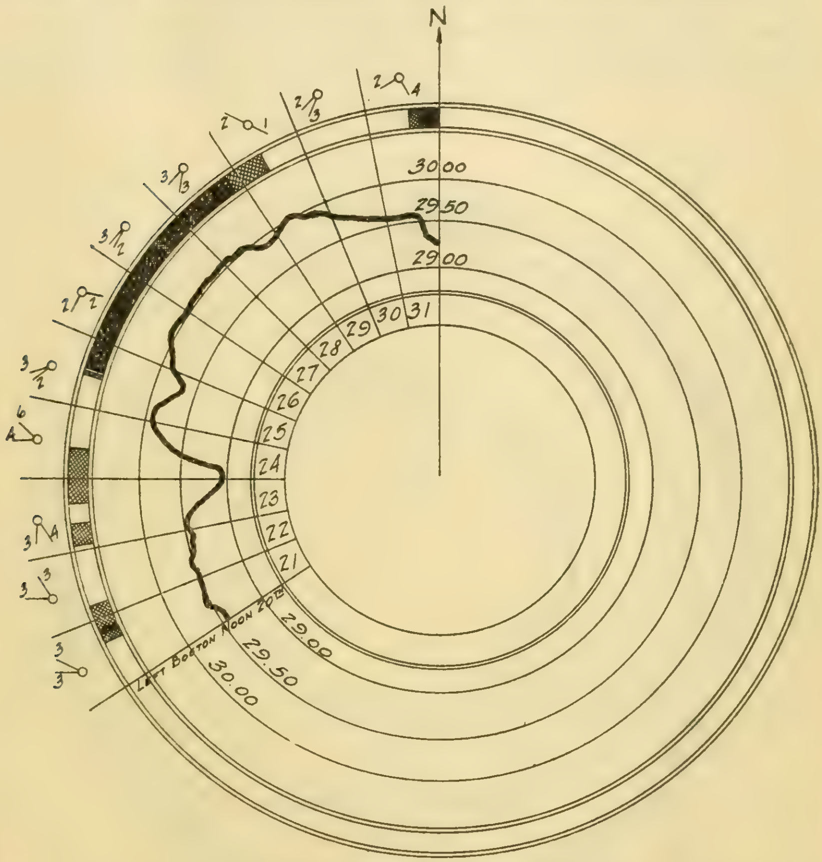

FIGURE 2.—March weather diagram. Inner figures show day of the month; the next band out contains the record of the atmospheric pressure; the next outer one indicates the degree of visibility (black areas are for visibility of less than two miles and cross-hatched areas for visibilities between two and four miles); the outer margin shows the average direction and force of wind per 12-hour periods, midnight to noon, and noon to midnight.

APRIL

Maximum air temperature, 52° F.
Minimum air temperature, 30° F.
Average air temperature, 38.7° F.
Visibility was less than 4 miles 26 per cent of time.
Visibility was less than 2 miles 18 per cent of time.

Fog and poor visibility prevailed during April just about normally; that is, to the average extent that the ice patrol has experienced during the past eight years. There were a number of days of high barometer and fine weather.

The barograph curve records no less than 12 depressions for the month. None, except the one that ushered in the first, were particularly deep where the patrol vessels were. Only three were able to give the ice patrol winds of gale force for as long as 12 hours, being for the most part very brief as well as shallow.

The fully developed cyclones of large area passed to the northeast over Newfoundland and Labrador, well to the north of the Grand

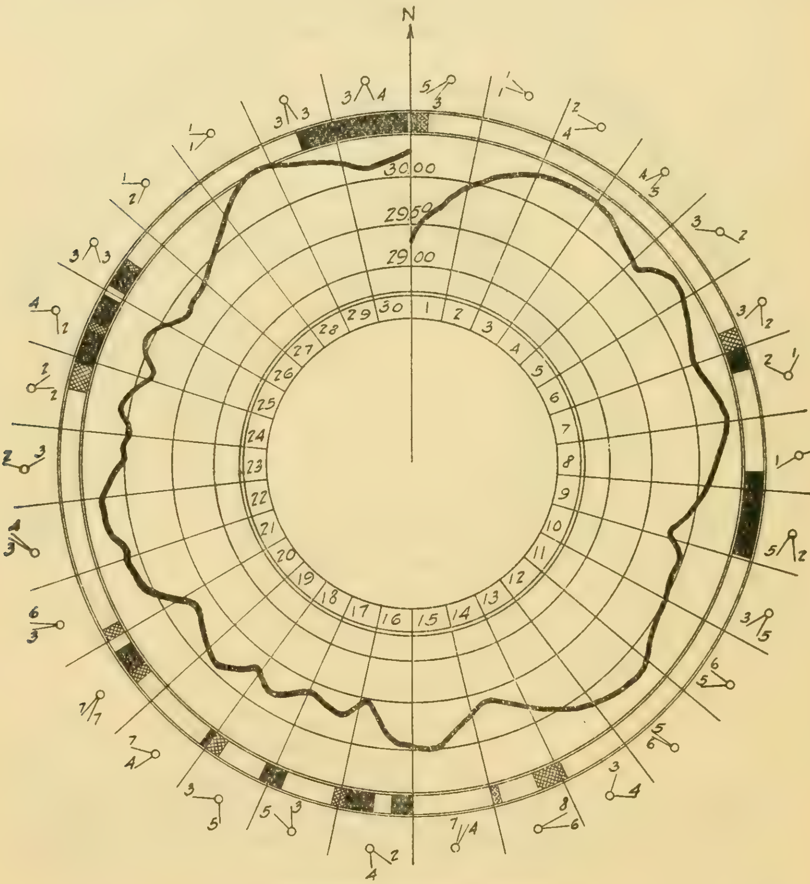

FIGURE 3.—April weather diagram.

Banks. The depressions that went over the patrol vessel were, many of them, secondaries of the larger Lows. Some of these small storms were noted over the States traveling along more or less parallel to the larger ones. Others, it seemed to the patrol, were born between the Grand Banks and the New England coast, as they were either detected by means of ship reports or not detected at all until they unexpectedly broke.

MAY

Maximum air temperature, 65° F.
Minimum air temperature, 36° F.
Average air temperature, 44.8° F.
Visibility was less than 4 miles 55 per cent of time.
Visibility was less than 2 miles 48 per cent of time.

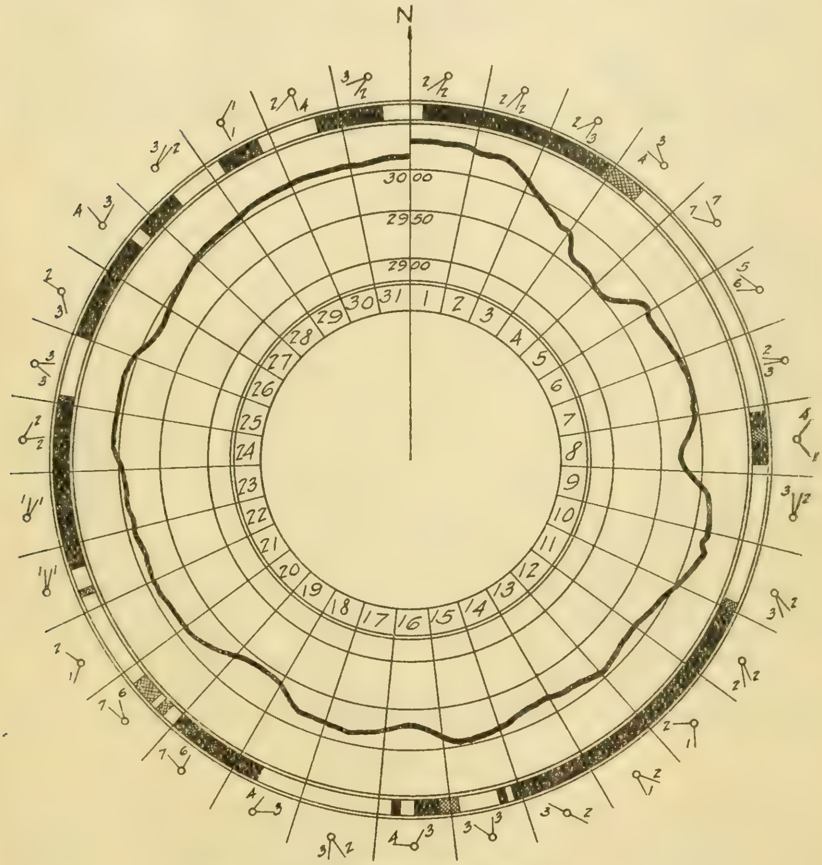

FIGURE 4.—May weather diagram.

About twice as much bad visibility as the patrol's 8-year average normal prevailed during May. On many of the foggy days the weather was really fine the fog being simply a conduction phenomenon limited to the layers of air chilled by contact with cold surface waters, with the sun shining in a perfectly clear sky overhead.

The month was featured by long periods of steady barometer about 30.00 inches in height. Moderate conditions prevailed and there was a marked slowing down and several stagnations in the march of Lows and Highs across the eastern half of North America and out

towards the patrol area. A ridge of high pressure that extended at times unbroken from Greenland to Bermuda was noted during the last half of the month.

The barometric gradients shallowed out markedly as compared with the preceding month. They became strongly suggestive of summer weather conditions with shallow Lows over the land and Highs over the ocean. Only five noticeable depressions are visible in the barometric curve. Four of these are of trivial depth. The most marked Low occurred early in the month, and the passing of its center was followed by nearly 24 hours of northwesterly gales. A few more hours of gales were experienced on the 8th, 19th, and 20th, and no others were encountered during May.

JUNE

Maximum air temperature, 69° F.

Minimum air temperature, 39° F.

Average air temperature, 49.2° F.

Visibility was less than 4 miles 47 per cent of time.

Visibility was less than 2 miles 40 per cent of time.

The ice patrol remained in effect during the first 22 days of June only. During this time poor visibility was experienced slightly in excess of normal. Winds of gale force were experienced only on the 15th. They were from the northwest as the majority of the patrol vessels' gales seem to be.

Summer-time conditions of groups of weak Lows over the continent and a High over the ocean from Bermuda to the northeastward were observed. The persistence of a low pressure area to the northeast of Newfoundland, as in April and early May, was noted.

There were about eight dips in the barometric curve but all were shallow where they passed the patrol vessel and were moving slowly.

GENERAL REMARKS

As in previous seasons a weather map was constructed twice daily on board ship for use in forecasting and in planning the operations of the patrol to the best advantage. The maps were obtained in large part from information in the general synoptic reports broadcast from NAA, Arlington, Va., at 0300 and 1,500 G. M. C. T., well supplemented by means of ship reports from the ice patrol area. A special daily forecast for the patrol vessel was received from the United States Weather Bureau.

The weather information on hand was always available to passing vessels on request. It was usually included, in part at least, in the routine ice broadcasts on account of the marked interest displayed by shipping early in the season in the weather being experienced by the patrol.

Twice daily a coded weather report was dispatched to the United States Weather Bureau, Washington, D. C., and at the end of each patrol cruise a more detailed report was forwarded by mail to the same office.

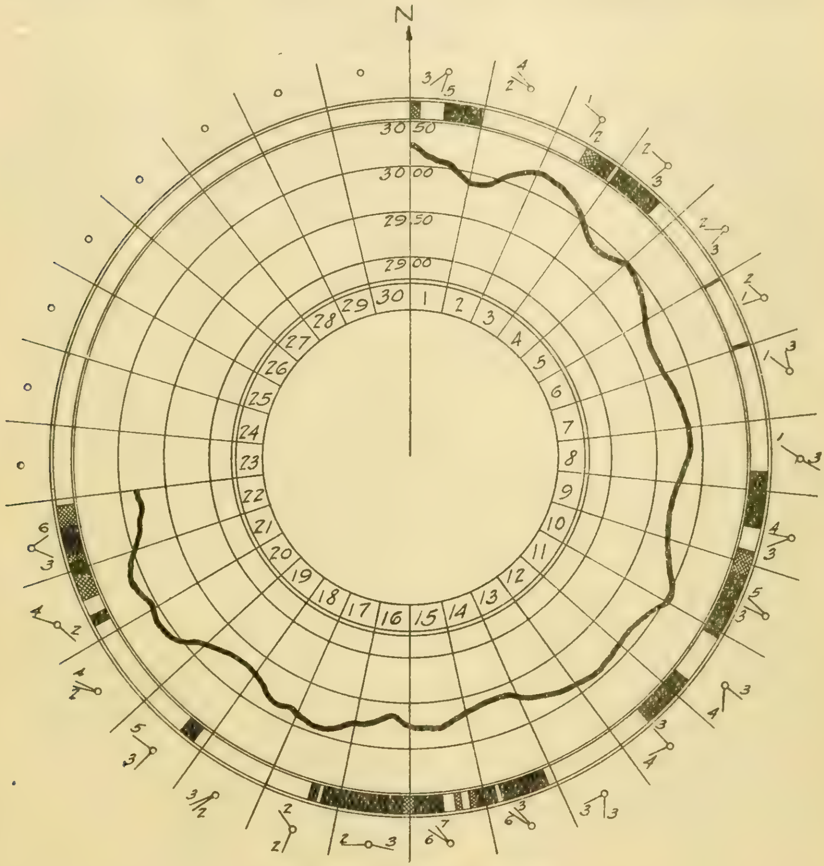

FIGURE 5.—June weather diagram.

Numerous special weather reports were sent to Cape Race for the benefit of trans-Atlantic fliers. During future patrol seasons the ice patrol should be of increasing importance as an observing and collecting station for up-to-the-minute weather reports of value to transoceanic aviation.

DEPTH SURVEY CARRIED OUT BY THE SONIC METHOD

Work was continued during 1928 with that part of the scientific program concerned with determining the bottom contours in the ice patrol regions. The echo or sonic method of depth finding was again used, the *Modoc* and the *Mojave* being both equipped with commercial instruments. Although one of the ice patrol vessels has been fitted with an experimental echo depth finder for several years, this year was the first one in which both patrol ships were equipped to obtain soundings rapidly and easily.

The following brief description is given for the benefit of those who may be unfamiliar with modern sonic sounding methods. Experiments have demonstrated the speed with which sound travels through water under various conditions of temperature, pressure, and salinity. If the time between the outgoing and the return by echo from the bottom of a short sharp note is measured, the depth of water can easily be found out. The principles are simple but in practice many complications arise and the instruments have to be elaborate and ingenious devices.

As might be expected the echoes are relatively much louder in shoal than in deep water. To get results in great depths the oscillators that produce the outgoing notes are strong and powerful. They are placed in the bottom of the ship near the keel. The echoes that come back are picked up by hydrophones in small tanks insulated from sound from all directions but downward.

The echoes are carried electrically to the bridge where an instrument amplifies the intensity of the signals by vacuum tubes until they are audible in head telephones. There is an indicator by the phones which revolves at a constant speed. When the sound goes out the pointer passes a zero mark on the scale. When the sound comes back it is only necessary to notice the number on the scale to which the marker is pointing to get the depth in fathoms instantly.

In shoal water, say under about 60 fathoms, the incoming sound comes back so quickly that it merges with and becomes almost indistinguishable from the loud outgoing one. A different system is used to get the depth in this case, a system much more accurate than that based on the coordination between the ear and the eye of man. The energy coming in from the strong echoes of shoal water is used to cause the flashing of a red neon tube electric light opposite the depth marks on the indicator. The light is carried along on the rotating

disk. As it passes the stationary zero mark on the scale a red flash is seen like a blurred pointer of fire about an eighth of an inch wide. Then when the incoming echoes come in there is another similar red flash opposite the proper depth on the indicator, if all is working well. Very often there are confusing stray flashes caused by breaking waves, outside noises, electric currents, etc.

It is indeed fascinating, and often comforting to the navigator, to be able to steam along taking 150 soundings a minute and watching the depths vary automatically with the red light with such precision as to delineate to the fathom every lump and hollow, every ridge and trough of the ocean floor. The white light or deep-water method is slower because of the time necessary to keep the incoming echoes properly compared with the right outgoing signals, and to allow time for the sounds to go down to the bottom and back at the rate of about 5,000 feet per second. When everything was working properly it was possible to take in depths of 1,000 fathoms or more, about as many soundings in every minute as would be possible with a wire and weight in a 12-hour day.

Notwithstanding their limitations and shortcomings the echo depth finders were invaluable navigational aids on ice patrol. They were especially useful in keeping track of the vessel's position during foggy and cloudy weather and at night, in telling exact points where certain contour lines were crossed, in locating the position of the ship on a line of position or radio bearing line, and in telling quickly the depth of water where an oceanographic station was about to be taken.

The soundings that were taken when the geographical positions of the ships were very well and fairly well known were saved in a smooth record book. Each sounding so recorded meant not just one depth but the mean of several carefully taken over, say, a minute of time, depending more or less on the plainness with which the echoes were heard. If they were faint many would be listened for in order to be sure to have the depth just right.

The accepted soundings were corrected by various amounts ranging up to about 5 per cent to allow for variations in the temperature, salinity, and compression of the water column. The corrections were deduced from the velocity chart published facing page 49 in ice-patrol Bulletin 15, season of 1926. Over 3,000 groups of soundings, taken when it was thought that either latitude or longitude could possibly be wrong by as much as 6 nautical miles, were discarded. Of course, soundings taken during fog, darkness, and in overcast weather were as accurate as those taken when it was clear; but when the position was in doubt, the values could not be used by hydrographers for amplifying the data on charts.

Lists containing over 1,200 good soundings and positions have been forwarded to the United States Hydrographic Office and to the

United States Coast and Geodetic Survey, for their information, in connection with improving the soundings data on the North Atlantic Ocean charts concerned.

As the instruments were a new type never before used on ice patrol, the following remarks are given regarding their action during the different partol cruises. These have been taken in substance from the cruise reports of the commanding officers on the several patrols.

At the beginning of the first cruise only up to 200 fathoms could be sounded with the sonic depth finder on the *Mojave*. Even this was of value in conducting the search for ice, being sufficient to give instant notice when to change course at such times as when approaching or leaving the 100-fathom curve of the Banks. As the patrol went on the depth that could be sounded increased to a maximum of 1,300 fathoms. It was believed that this was due to smoother water which lessened the so-called water noises from whitecaps, and to increasing experience on the part of the operators, for the machine itself had practically no adjustments made to it. It was very encouraging when soundings could be taken in the deep water because of the comparative scarcity of depth values on the chart in the area being searched. The greatest care was taken to keep track of the ship's position at all times in order that the locations of the soundings might be accurate.

The second cruise was started with a systematic gathering of fathometer depths on the *Modoc*. The officers of the deck, by taking soundings every 15 minutes, quickly gained experience in deep water depth sounding and obtained a number of particularly valuable records. Due to the small amount of wave motion and consequent quietness on April 8, audible echoes were obtained in depths up to 2,000 fathoms. On April 10 the apparatus broke down and could not be adjusted until engineers from the maker boarded the vessel at Halifax after the end of the cruise.

It was routine during the third cruise for the officers of the deck on the *Mojave* to get the depth by the echo method every 15 minutes while cruising and every half hour while drifting. Only occasionally was there difficulty, as when the signals were weak in the phones. In all 1,700 successful echo soundings were recorded in the rough book on the bridge during the cruise. Of these 400 were preserved for use in checking the North Atlantic charts. The difference was due to the fixed policy of rejecting for hydrographic use all soundings made when the position of the ship was in doubt due to lack of good sights.

The fourth cruise produced only 22 values of depth for the smooth record. The high percentage of bad visibility, coupled with inability to hear the fathometer echoes in the extremely deep water, where

most of the time was spent, prevented a more numerous result. The weak signals seemed to be caused by trouble in the sound-receiving and amplifying devices. The oscillators in the hull sent out good signals, but it was very difficult to pick up the echoes in the head telephones.

The apparatus worked well during the fifth cruise. Soundings up to 2,600 fathoms were obtained. Besides tabulating for reference 251 depths taken when the ship's position was well fixed, the instrument was an invaluable aid in locating the ship during thick and overcast weather.

The sixth patrol cruise produced 97 values for the depth records; 330 soundings were obtained but the majority were thrown out on account of doubtful positions due to the impossibility of getting enough sights. The short seventh cruise furnished 31 good soundings to be added to the season's total.

It was noted that when the depth finders were in good working order, results in water up to 1,000 fathoms in depth could usually be counted on. The deepest soundings were all made under especially quiet wave and sea conditions. Very likely on ships using less electricity than the electric-drive ice-patrol vessels better results would be obtained. The Diesel-drive cutter *Marion*, on the *Marion* Expedition, shortly after the termination of ice patrol could sound with her instruments of the same make down to 2,000 fathoms consistently, so long as the radio apparatus was not being used. Whenever the near-by transmitter was sending the fathometer was strongly affected with induced noises that entirely blotted out the incoming echoes. Such a condition did not exist on the ice-patrol cutters where the radio room was a long distance aft of the bridge, but no doubt some of the noises that interfered with the hearing of weak echoes were picked up from the numerous strong electric fields on board.

ICE OBSERVATION

The ice particularly watched and tabulated by the international ice patrol is that which, in passing south along the east coast of Newfoundland, gets south of the forty-eighth parallel of latitude. Every recent annual report of the International Ice Patrol Service has contained a section on ice observation. The reader is referred to the 1926 report for a statistical compilation of ice observed in the years to and including 1926, and to the 1927 report for the ice conditions prevailing that year. The figures are based during the actual ice-patrol season on the reports to and the observations of the ice patrol vessels themselves. During the remainder of the year the reports of ice contained in the weekly Hydrographic bulletins of the United States Hydrographic Office and special reports from Cape Race radio-compass station are depended on. A number of ice charts and a discussion of ice conditions month by month during 1928 are given below:

JANUARY

There were no reports of ice during January, 1928

FEBRUARY

No bergs were reported by trans-Atlantic vessels during the month from south of the forty-eighth parallel. Field ice from the Gulf of St. Lawrence was reported from between Cape Breton and Sable Islands. Field ice was reported from several other localities, most of which were north of 47° N., and all of which were north of 46° 30′ N. The other reports were confined to areas off the Newfoundland coast between Cape Race and St. Johns, to the vicinity of 48° 00′ N., 49° 30′ W., and to the vicinity of 47° 00′ N., 47° 30′ W.

MARCH

During this month a number of bergs drifted south along the eastern edge of the Grand Banks, but only one got south of the forty-fifth parallel. Bergs were thickest along the eastern edge a little to the north of this latitude. They were on the whole distinctly below normal for the month in number, however. One berg was reported from a few miles west of Flemish Cap. A few bergs were located along the forty-eighth parallel to the westward of the forty-seventh meridian.

Field ice reached its greatest southerly extension for the year during March. There were two reports of the Gulf of St. Lawrence

PLATE VI.—MELTING FAST IN 60° WATER SOUTHEAST OF THE GRAND BANKS. THIS ICEBERG IS THE SAME ONE AS THAT SHOWN IN PLATE III. IT WAS CLOSELY WATCHED BY THE ICE PATROL FOR 16 DAYS WHILE IT DRIFTED IN A GREAT LOOP FOR OVER 480 NAUTICAL MILES. JUNE 2, 1928

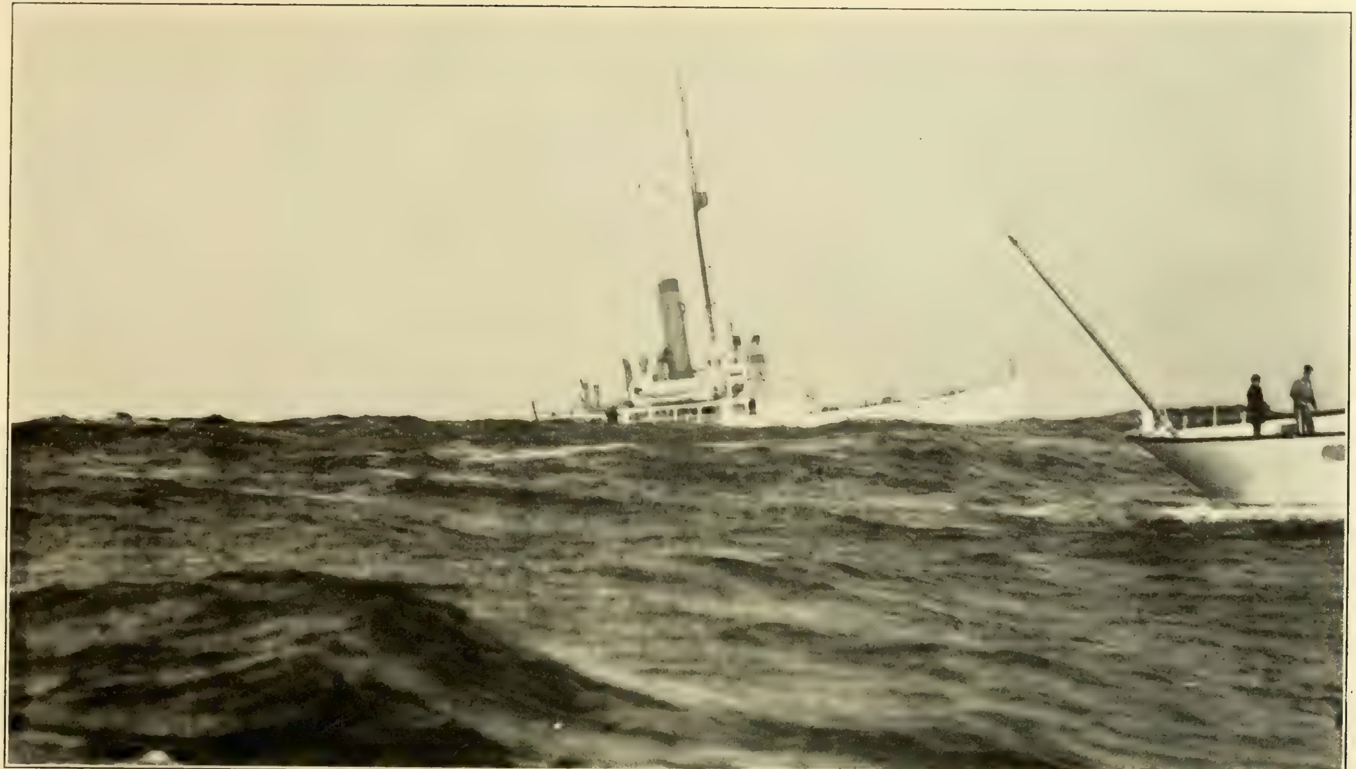

PLATE VII.—THE "MODOC" (LEFT) AND "MOJAVE" (RIGHT) MAKING CONTACT ON APRIL 21, 1928, FOR THE TRANSFER OF THE OCEANOGRAPHIC PARTY AND PATROL RECORDS. THE HEAVY SWELL MADE THE TRANSFER ACTIVITIES AN EXCITING TASK

pack from between Sable Island and Cape Breton Island. The most southerly report was one of this ice from the vicinity of 44° 30′ N., 60° 00′ W. The Canadian authorities in the Department of Marine and Fisheries, Ottawa, at the present writing have more detailed information regarding ice conditions in this western sector.

In the vicinity of the ice patrol's activities field ice was reported as extending northward from 46° 20′ N., 50° 00′ W., and northward from 45° 50′ N., 47° 30′ W. The wording of the several reports indicated that the ice south of the forty-eighth parallel was neither close nor heavy. There were no reports of berg or field ice from along the east coast of Newfoundland, but not enough steamers were traversing the area off this coast to cover it at all well.

APRIL

A great increase in the total number of bergs was noted during April. The feature of their distribution was their scattered southeasterly drift past Flemish Cap and across the C United States-Europe steamship tracks. One berg was reported from an extreme easterly position in 47° 00′ N., 40° 57′ W. Two other bergs were reported from positions east of the forty-third meridian, between the forty-sixth and forty-seventh parallels. The southeasternmost berg of the month disintegrated in the vicinity of 44° 10′ N., 43° 20′W.

Further to the westward one berg was carried south of 43° N. in the vicinity of the forty-ninth meridian. All of the bergs that got south of 43° during the following months did so in the neighborhood of this same meridian.

The bulk of the April bergs were situated along the eastern edge of the Grand Banks from 45° N., 49° W. to 48° N., 46° W. Again, no bergs were reported from near the Newfoundland coast. Rather remarkably, none were reported from west of the fiftieth meridian. The continued absence of steamer traffic from this area makes this negative evidence weak, however. The probability is that there was a considerable quantity of unreported ice there, both berg and field.

The last report of field ice in the Grand Banks area for 1928 was received on the 10th from the vicinity of 47° 30′ N., 48° 40′ W. The Canadian ice patrol service was inaugurated on April 12. On the 13th this service broadcast that there was field ice from the longitude of Cape Breton Island to Cape Race, the fields being heavy to the east and lighter to the west.

MAY

As is normally the case, May saw a greater number of bergs south of the forty-eighth parallel than any other month. Their extreme southeasterly drift was checked by the rapid extension northwestward toward Flemish Cap of Gulf Stream and solar warming. They

were located further west on the average than during the previous month. This caused them to stop in the dead water or to strand along the north edge of the Grand Banks in the region from 46° 40′ N., 52° 00′ W., to 47° 50′ N., 49° 30′ W. A few were carried to the westward in the branch of the Labrador current that sets past Cape Race through the Gulley. The westernmost berg of this group just crossed the fifty-fourth meridian off St. Marys Bay, Newfoundland.

Seven bergs from the large number concentrated along the northern half of the eastern edge of the Grand Banks during the preceding month escaped being stranded along the edge or being curved off to the northeast by the inshore edge of the warm Gulf Stream influence. These seven floated down the narrow band of cold water along the eastern edge off the Tail of the Banks and were swept across the forty-third parallel between the fiftieth and forty-eighth meridians. By the 31st one of them reached 40° 47′ N., 48° 54′ W. Three days later this berg reached its extreme southerly position in 38° 59′ N., 48° 57′ W., which was 126 sea miles farther south than any of the 1927 ice drifted.

No field ice was reported from the Grand Banks area in May. The only field ice report to be received by the ice patrol during the month was one of the St. Lawrence pack that by then had dwindled inshore to the vicinity of 47° 40′ N., 60° 00′ W. The ice season in the gulf was open and light and terminated unusually early. For authoritative information regarding field ice to the west of Cape Race, one should address the Department of Marine and Fisheries, Ottawa, Ontario, as that department is in charge of the ice-patrol service conducted by the Canadian Government for the benefit of shipping entering St. Lawrence Gulf and River ports.

JUNE

Only eight different bergs were sighted or reported from south of the forty-sixth parallel during June. Six of these were south of the forty-third parallel. These six were all disintegrated during the first week of the month by the relatively high surface temperatures resulting from continued solar warming and Gulf Stream mixing. Three reasons can be given for the fact that no bergs are known to have crossed the forty-third parallel after June 5: 1. Probable actual weakening of Labrador current. 2. Temperatures of surface layers south of forty-eighth parallel well above freezing, even in the Labrador current, which, coupled with 1, would cause bergs to disintegrate before getting far south. 3. Failure of large supply of bergs to Labrador current where it rounds the northeast promontory of the Grand Banks. The ice was on the average even farther west in the ocean during June than it was during May. Many of the bergs were close to and stranding upon the coast of

the Avalon Peninsula of Newfoundland. Two groups of bergs were stopped or stranded on the northern part of the Grand Banks in the vicinity of 47° 20′ N., 50° 50′ W., and 47° 30′ N., 49° 40′ W. Neither of these groups was located far enough to the eastward to be favorably situated to serve as the origin of southerly berg drifts.

Vessels apparently began using the Belle Isle steamship tracks on the relatively early date of June 21, for 23 bergs and several growlers were reported to the international ice patrol on that date from between Greenly Island and 52° 30′ N., 53° 00′ W. No field ice was sighted by or reported to the patrol vessels during June.

JULY

Fifty-five bergs were south of the forty-eighth parallel. All of them were within a 50-mile radius of Cape Race, Newfoundland.

AUGUST

Five bergs were south of the forty-eighth parallel. All were in the same area as the July bergs.

SEPTEMBER

No bergs were south of forty-eighth parallel in September.

OCTOBER

Four bergs drifted south of forty-eighth parallel during the month. Three of these were close to Cape Race and one was about 120 miles to the eastward.

NOVEMBER

Four bergs got south of the forty-eighth parallel. Ice was noticeably farther east in the ocean than in four preceding months.

DECEMBER

No bergs south of forty-eighth parallel up to time of finishing this manuscript for printer, January 4, 1929. Very likely a few reports of ice sighted in December are yet to come in.

The above monthly discussions and the charts following this section give a general idea of the ice distribution southeast of Newfoundland below the forty-eighth parallel throughout the year. For a narrative account of the ice seen, together with the attendant observations and conditions, see the 1928 cruise reports at the beginning of this pamphlet.

As in former years the ice patrol kept track of and recorded the drift of as many bergs as possible during the season. The paths taken are shown on Figure 12. The longest track is over 480 sea miles in length and represents the results of 16 days of actual trailing and tracking by the ice patrol vessels.

Figure 12 also shows the known risks from bergs that the United States-Europe steamers experienced in April, May, and June, 1928. The ice-patrol broadcasts help to minimize these risks, but in times of fog and darkness real safety can lie only in radically reduced ship speeds and judicious caution.

SUMMARY

Month	Bergs south of 48° N. in 1928	Bergs south of 43° N. in 1928	Bergs south of 48° N. normally	Bergs south of 43° N. normally
January	0	0	3	0
February	0	0	10	1
March	14	0	36	4
April	156	1	83	9
May	190	7	130	18
June	87	6	68	13
July	55	0	25	3
August	5	0	13	2
September	0	0	9	1
October	4	0	4	0
November	4	0	3	0
December	0	0	2	0
Total	515	14	386	51

From the above figures it will be seen that the total number of bergs known to have been south of the forty-eighth parallel in 1928 was considerably above normal during the greater part of the heavy ice season. On the other hand, the number of bergs to drift south of the forty-third parallel was distinctly subnormal. Some of the latter bergs got into the circulation southeast of the Tail of the Grand Banks, however, and attained extremely low latitudes before melting.

Field ice was distinctly below normal in amount about the Grand Banks as well as inshore to the westward. Its southerly extension was never great and it disappeared from the picture relatively early.

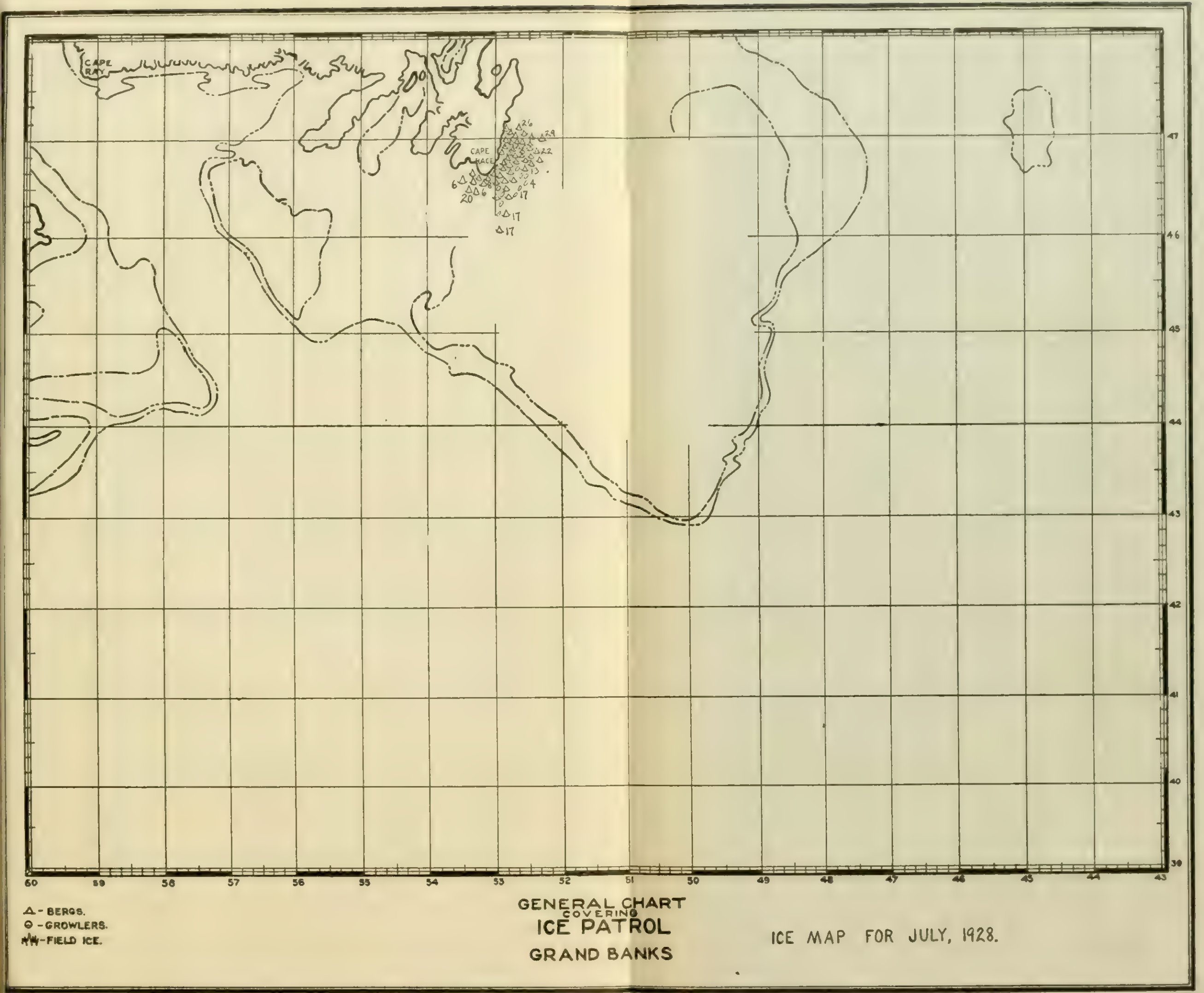

FIGURE 11.—July ice map. 55 known icebergs were south of the 48th parallel during the month

33382—29. (Face p. 64.) No. 6

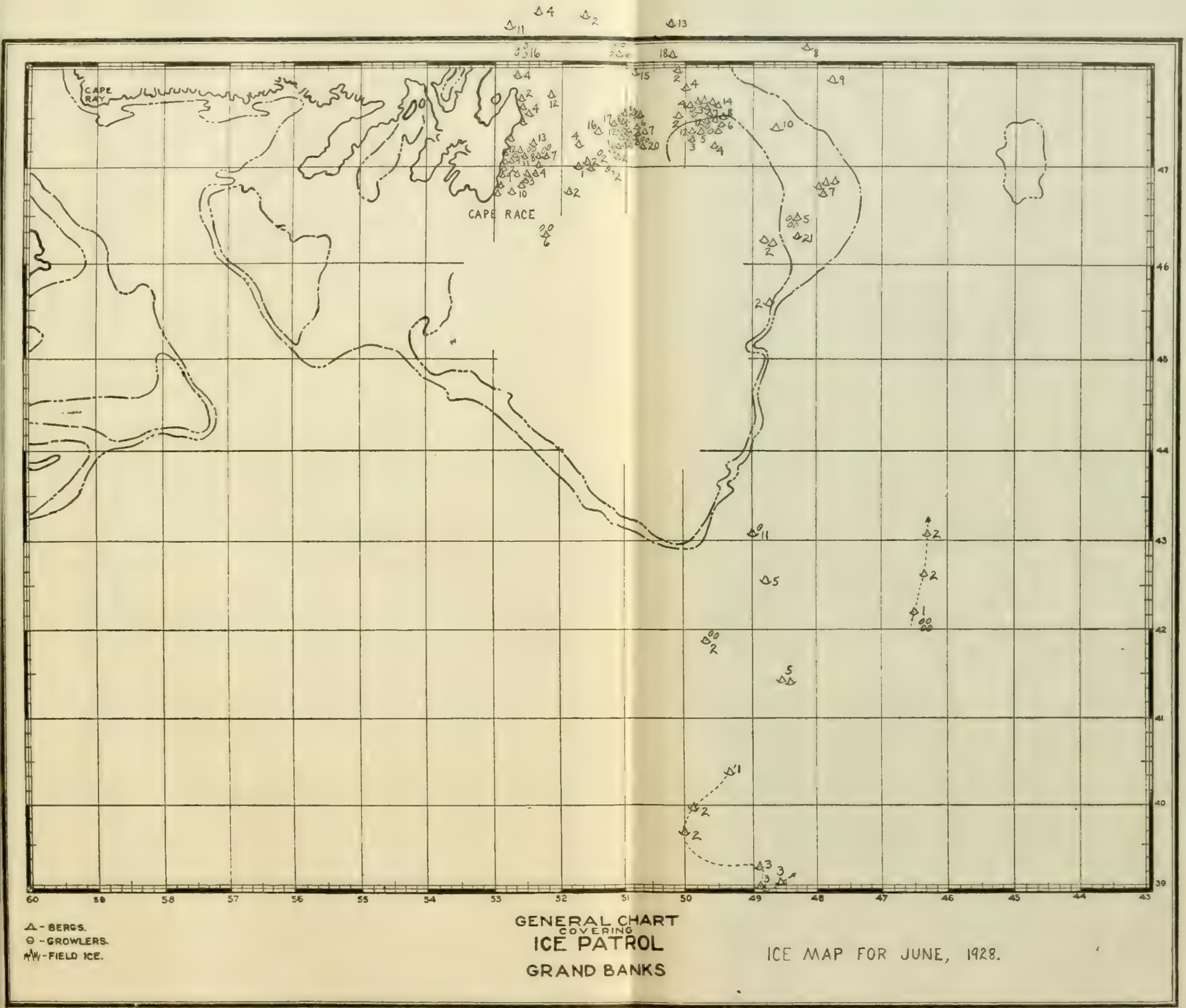

FIGURE 10.—June ice map. 87 known icebergs were south of the 48th parallel during the month

33382—29. (Face p. 64.) No. 5

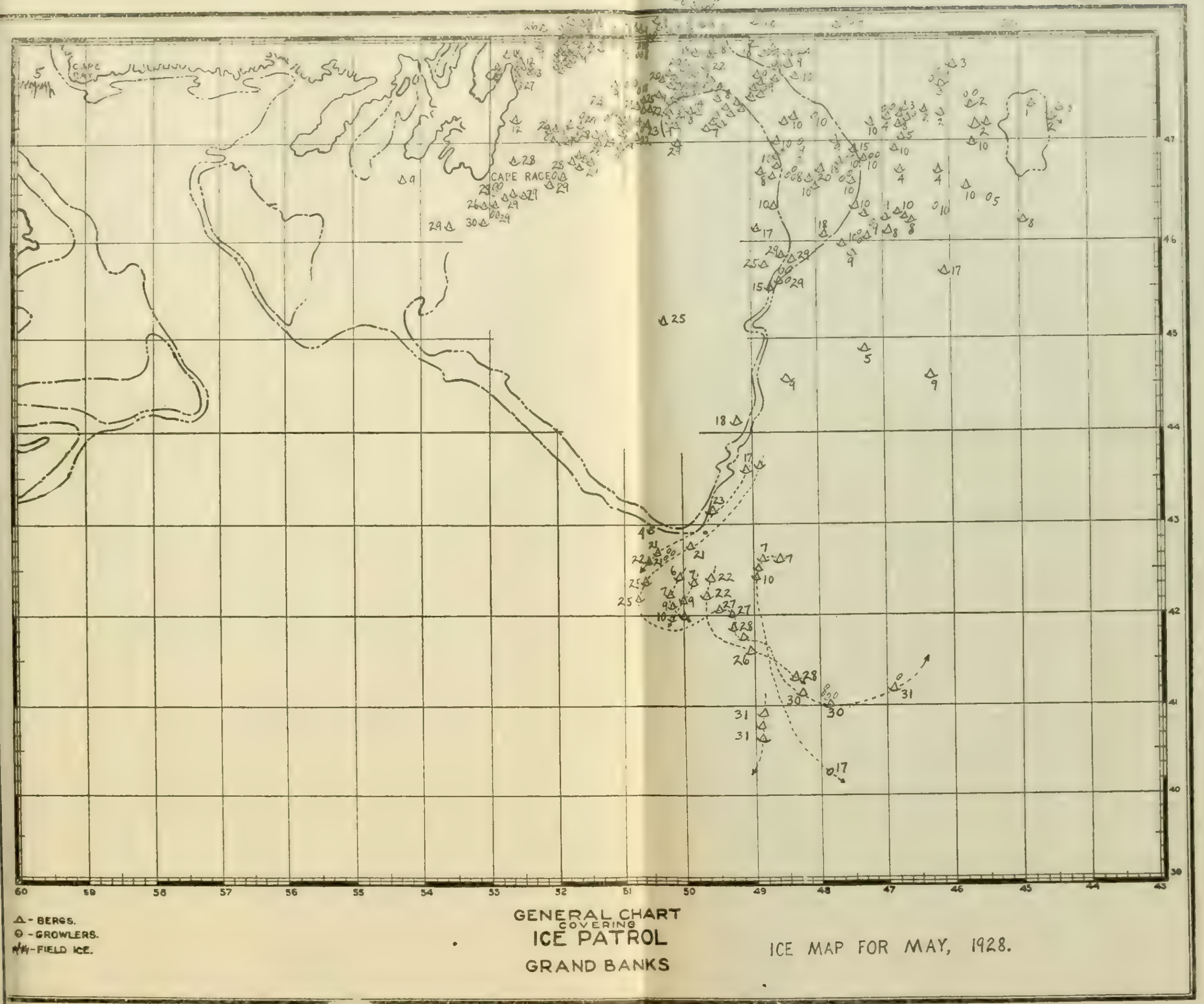

FIGURE 9.—May ice map. 190 known icebergs were south of the 48th parallel during the month

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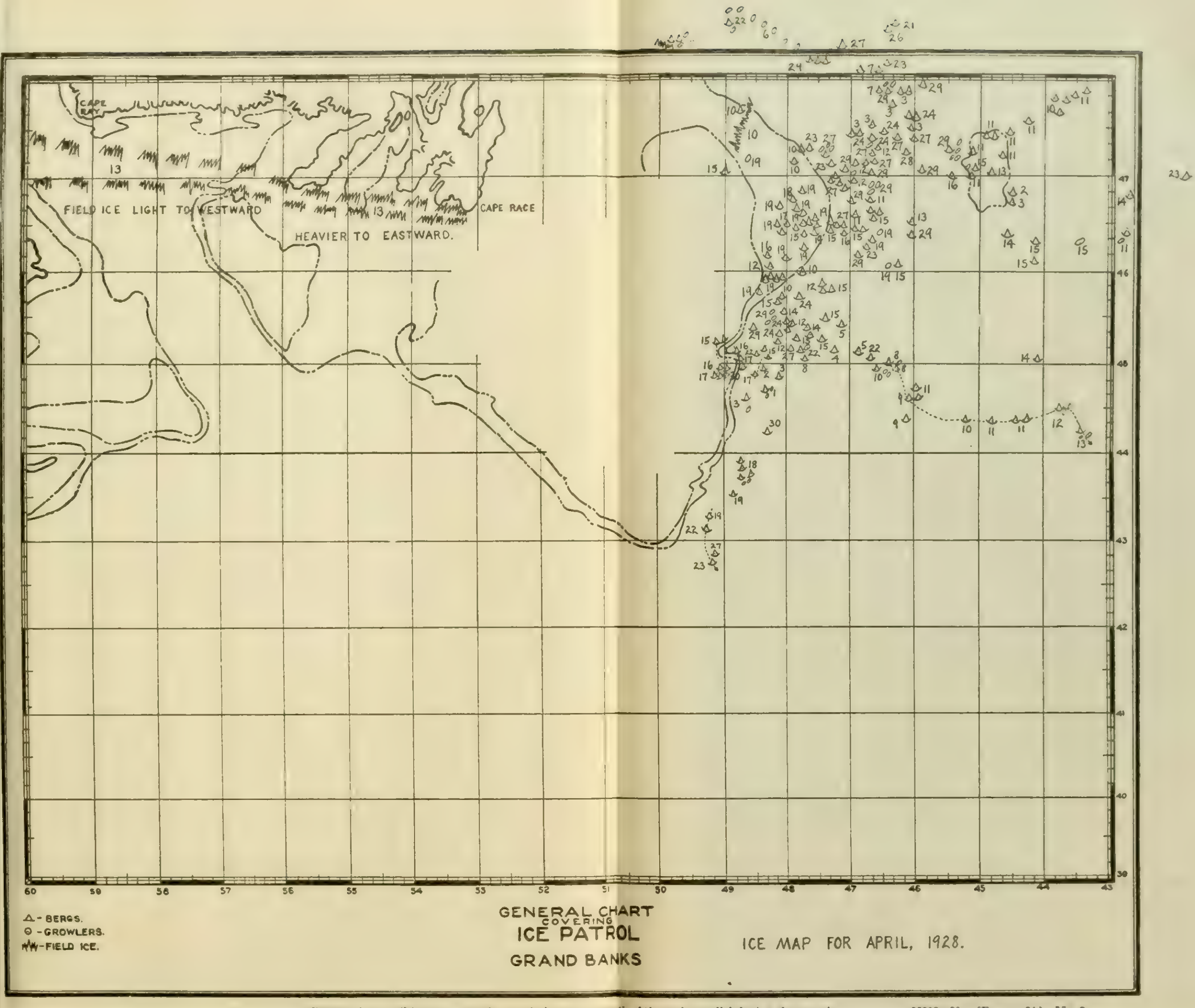

FIGURE 8.—April ice map. 156 known icebergs were south of the 48th parallel during the month

33382—29. (Face p. 64.) No. 3

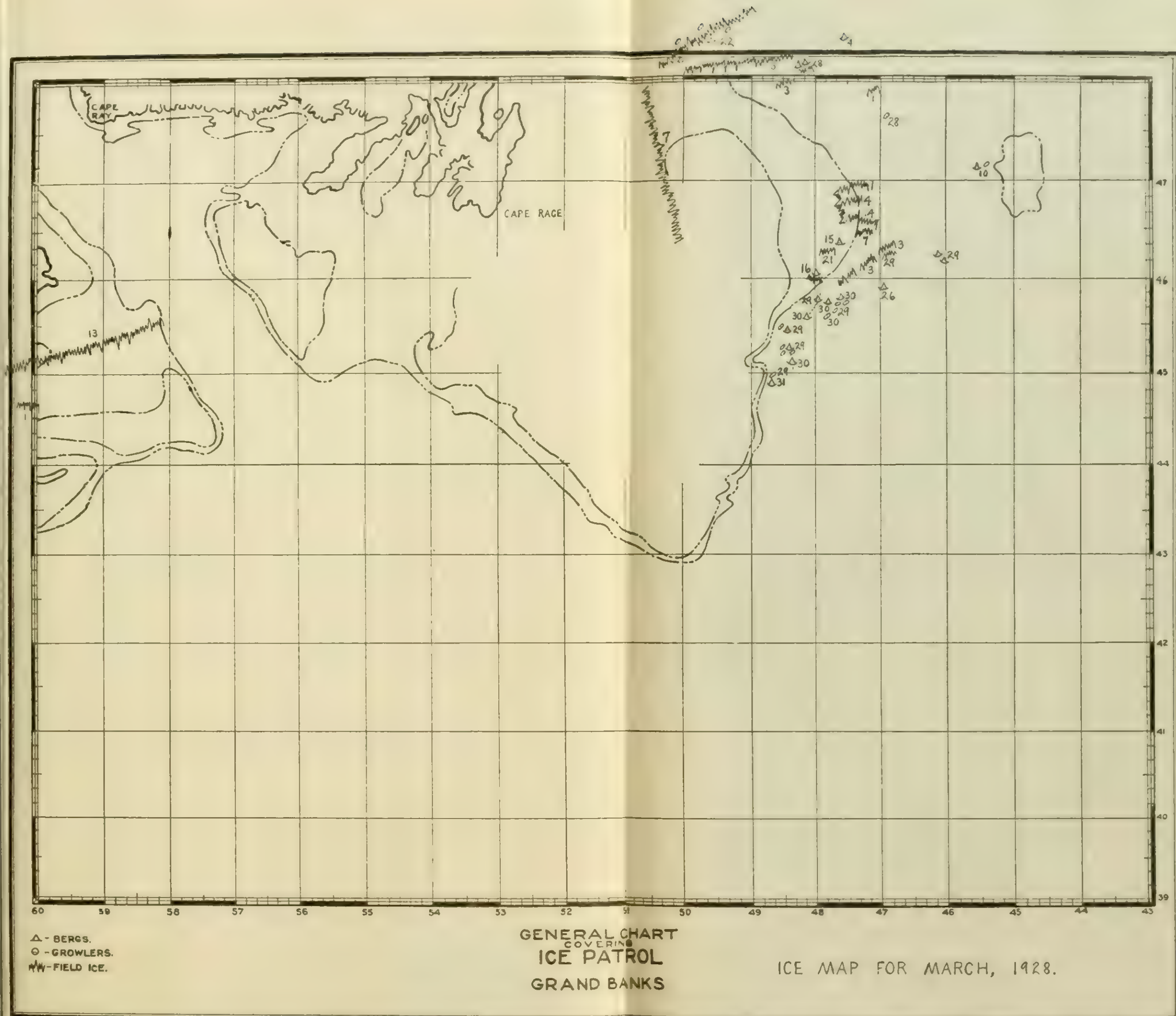

FIGURE 7.—March ice map. 14 known icebergs were south of the 48th parallel during the month

33382—29. (Face p. 64.) No. 2

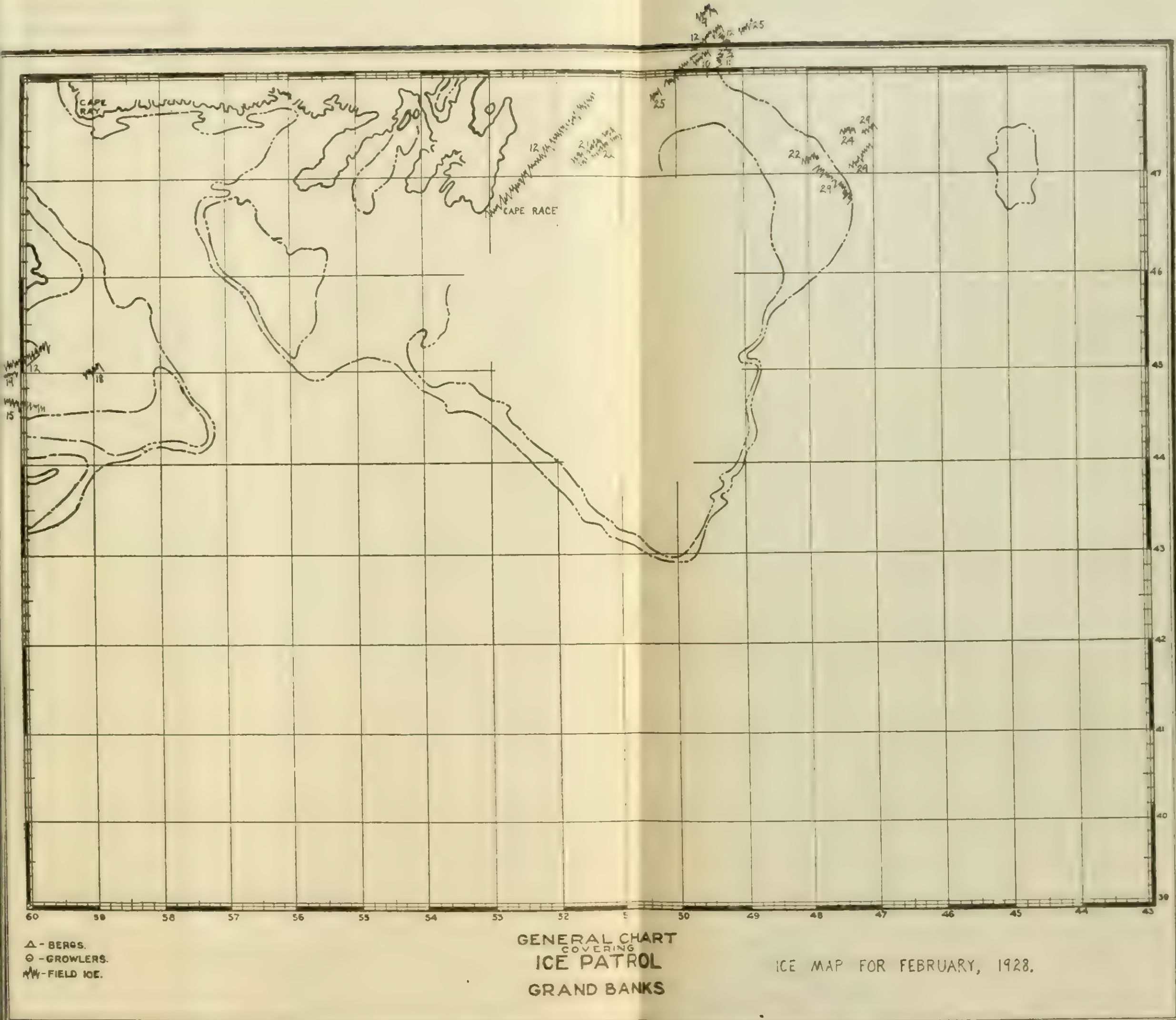

FIGURE 6.—February ice map. No known icebergs were south of the 48th parallel during the month

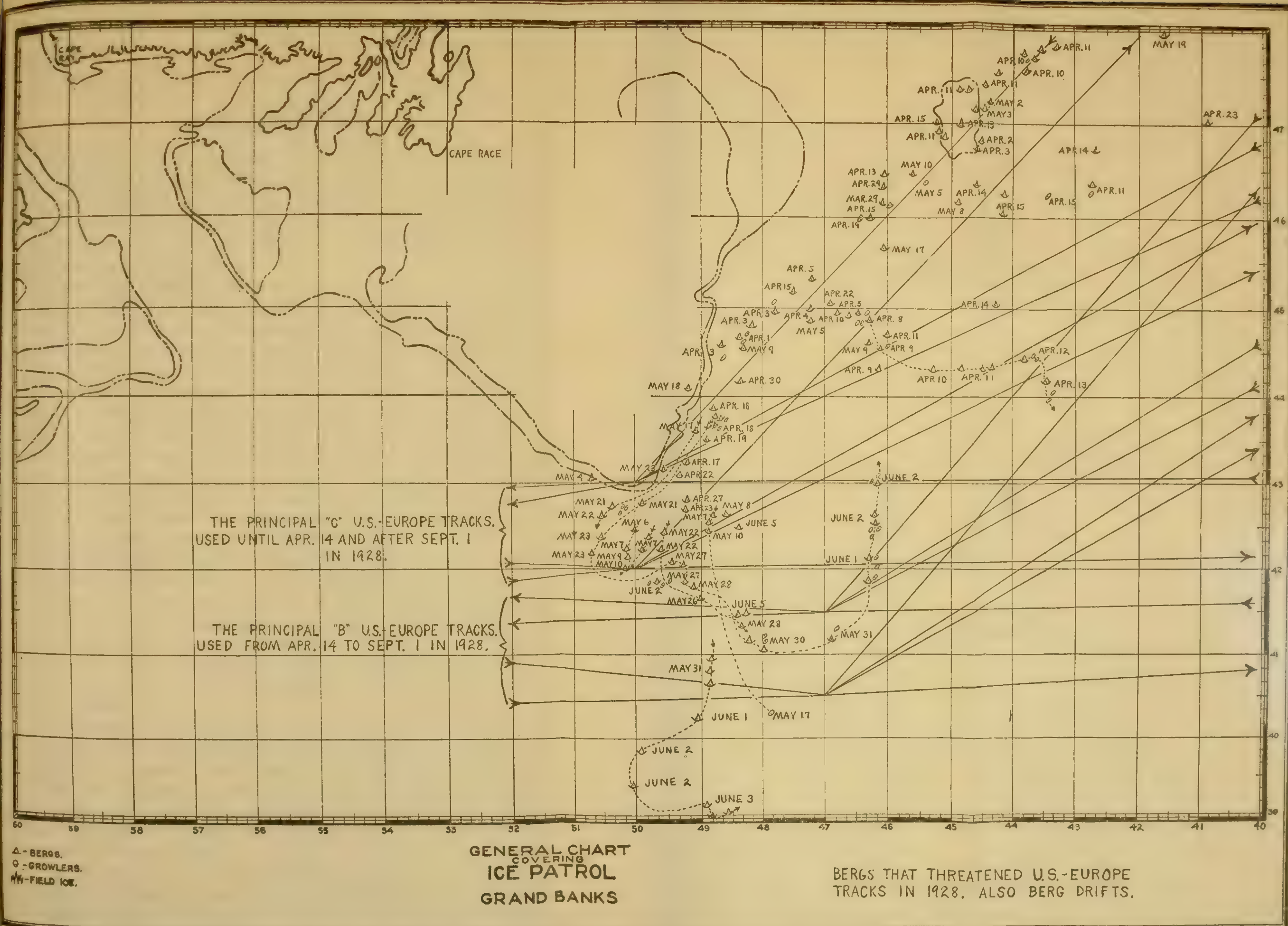

FIGURE 12.—Positions of icebergs that approached or crossed the United States-Europe steamship tracks in 1928, together with drift tracks of all icebergs that the Ice Patrol was able to follow

OCEANOGRAPHY

During the ice patrol season of 1928 no detailed large area current maps were made by the hydrodynamic method as the threatening ice situation prohibited intensive oceanographic work. The United States-Europe C tracks were adhered to by shipping until April 14, when they had either been crossed or were immediately menaced by no less than 28 bergs.

The patrol recommended the shifting of the tracks to more southerly ones many days before the desirable action was taken. No reason is known why the C tracks were adhered to so much longer than usual in 1928, unless it was that the trans-Atlantic track conference again expected a fairly safe northerly distribution of ice such as was experienced in 1927. When the B tracks were finally used they were adhered to longer than absolutely necessary. Looking back at the actual manner in which ice was distributed month by month it can now be seen that had the tracks been shifted south to B one month earlier than was done and shifted back to C two months earlier than was done, 1928 would have seen one month's less use of the longer tracks and at the same time have had a safer distribution of sum total ocean crossings than was actually the case.

After the B tracks went into effect the patrol was but little freer to take stations than before. The drifts of several bergs actually on or across the B tracks had to be followed. The rest of the time had to be devoted to searching for new bergs coming down to and threatening the B tracks from the little crossed fog areas immediately to the north. The oceanographic stations, being secondary in importance to the actual ice scouting, had to be taken about when and where possible.

The positions of the 95 stations taken during 1928 are shown in Figure 13. The station distribution would have been differently arranged if the patrol vessels had been less under the necessity of scouting and trailing bergs as above noted, and many more stations would have been taken also, approaching the ideal of a close checkerboard arrangement of observations, repeated every two weeks over the areas to be investigated.

The scientific observer and his oceanographic assistant were different persons than those who took and worked out the stations during previous seasons. The new men gained considerable experience during the course of the spring.

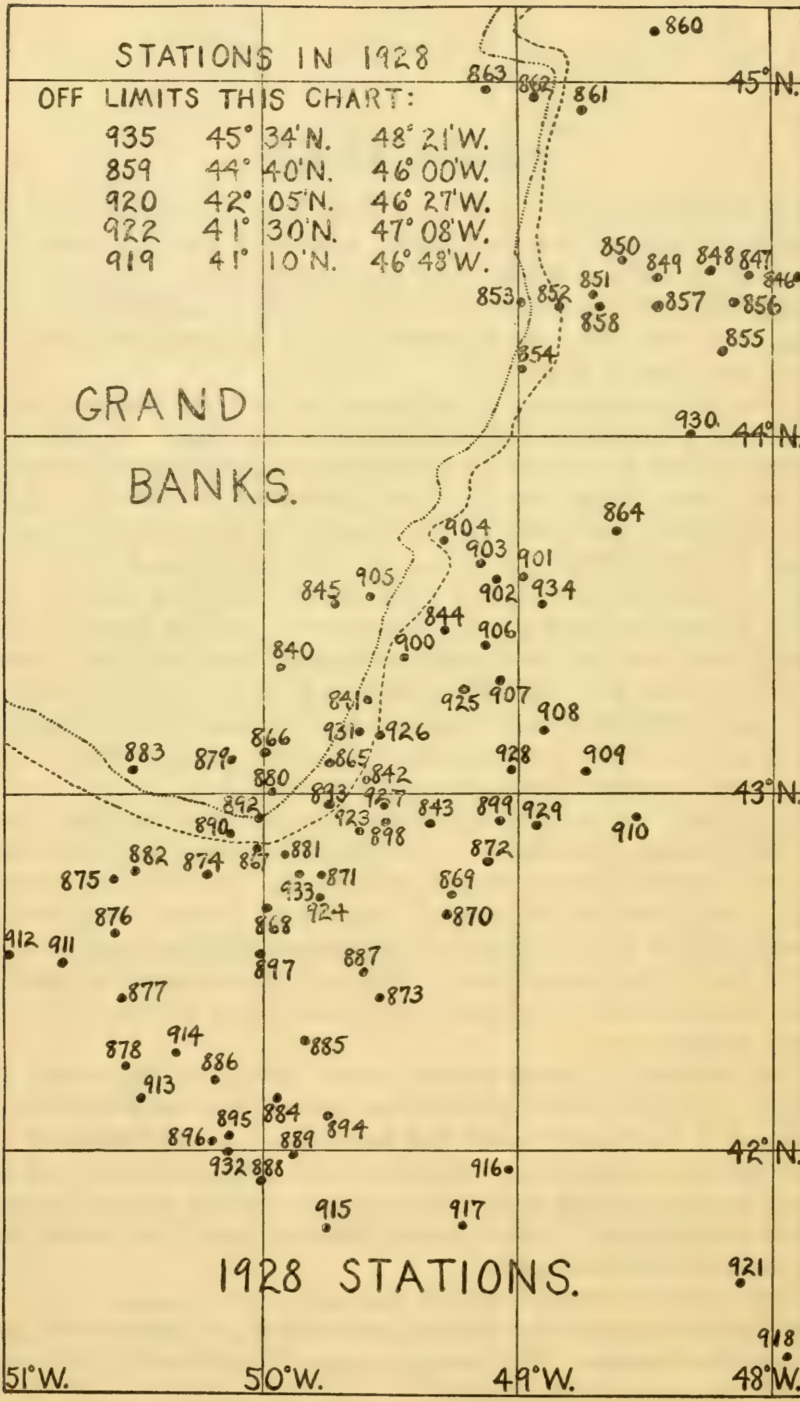

FIGURE 13.—Distribution of oceanographic stations

Throughout 1928 the salinities were determined and the stations were computed at sea, as in 1926 and 1927, very quickly after the actual stations were occupied. In running the electric salinity cabinets the need was felt for standard water of dependably known salinity for calibrating and frequent check purposes. The carboys of tested water on hand from the previous year were of somewhat doubtful salinity.

Graphical curves of temperature with depth should be made at every station before the ship is started ahead. Questionable—that is, seemingly erratic or unreasonable—values of temperature should mean the retaking of the whole station at once, or at least the retaking of the doubtful and adjacent levels. Irregular values of salinity should be watched for also in the same manner. When they are found the water from the level in question should be retested, this time in another electric cell from the one first used. As the salinities can not be determined for some little time after the stations are finished, the ship will always be too far from the station to permit the procuring of a new bottle of water. If reasonable results can not be obtained, interpolation between adjacent levels must be resorted to. Where interpolated values were used in 1928 the fact is noted in the table of station data. So delicate is the balance of the various water masses in the sea that the greatest methodical care in all work connected with the taking and computing of the stations is the only insurance against gross errors in the final results.

The 1928 stations have been divided into seven groups or sets as shown in figures 14 to 20. Each set is made up of stations taken within a period of time short enough to permit the hydrodynamic values to be compared with reasonable safety for general current work.

The arrows on the current charts were put in much like wind arrows could be put on a weather map if the barometric pressures at a number of observing stations were known. The four group figures by the dots that represent the various stations show in tenths of dynamic millimeters the height of the average sea surface above 728 dynamic meters that must have existed above the 750 decibar pressure level. (A decibar is a pressure equal to one-tenth of an atmosphere. A dynamic meter is approximately the same as an ordinary meter. It is a vertical unit of distance that varies from place to place in the same ratio as the force of gravity varies.) The four figure distances were computed from the known distribution of salinity and temperature in the water of the various levels at each station.

Seven hundred and fifty decibars was the deepest pressure level that was sampled during the 1928 ice patrol. If more time were available it would have been advantageous to go down to the 1,000 or even the 1,500-decibar levels at the deeper stations in order to be sure of determining all the current. It is believed, however, that not a

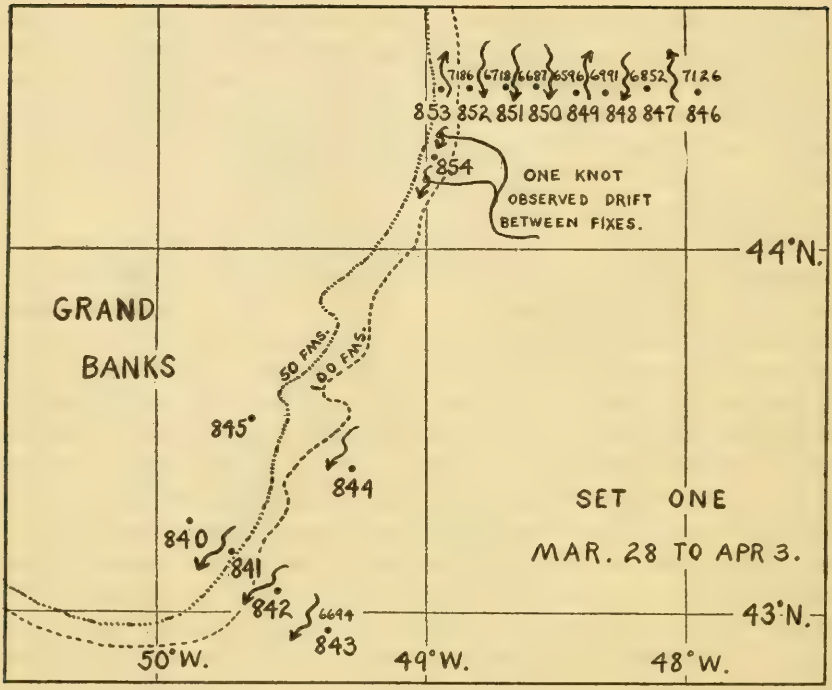

FIGURE 14.—Current tendency diagram

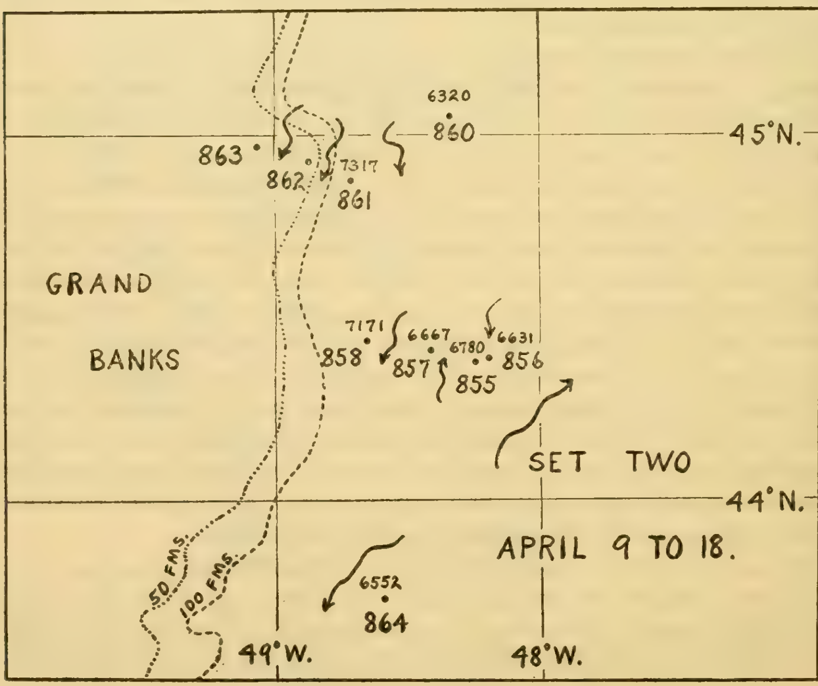

FIGURE 15.—Current tendency diagram

great deal of accuracy is lost by neglecting the small variations in conditions that usually exist below the 750-decibar pressure level in the sea.

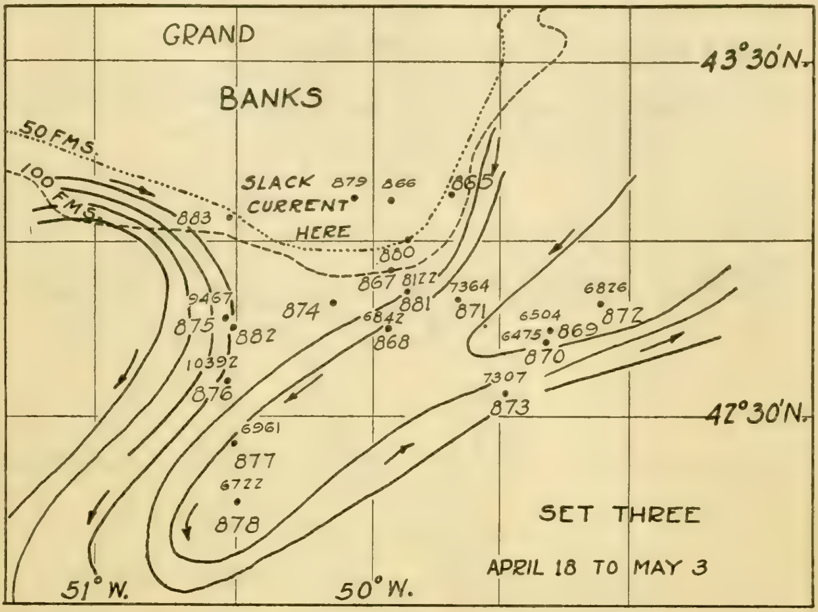

FIGURE 16.—Current map

Where the four-group figures are larger it means that, because it is lighter, the water is puffed up so that the average height of the sea surface is heaped up more above the local mean sea level than where

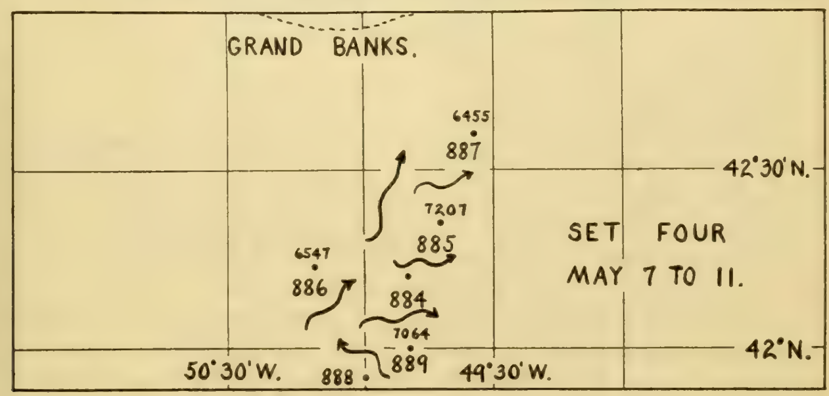

FIGURE 17.—Current tendency diagram

the figures are smaller. Highs in the sea are thus formed, and these north of the equator, both by theory and by actual observations in many open seas, have clockwise currents circling about them. These

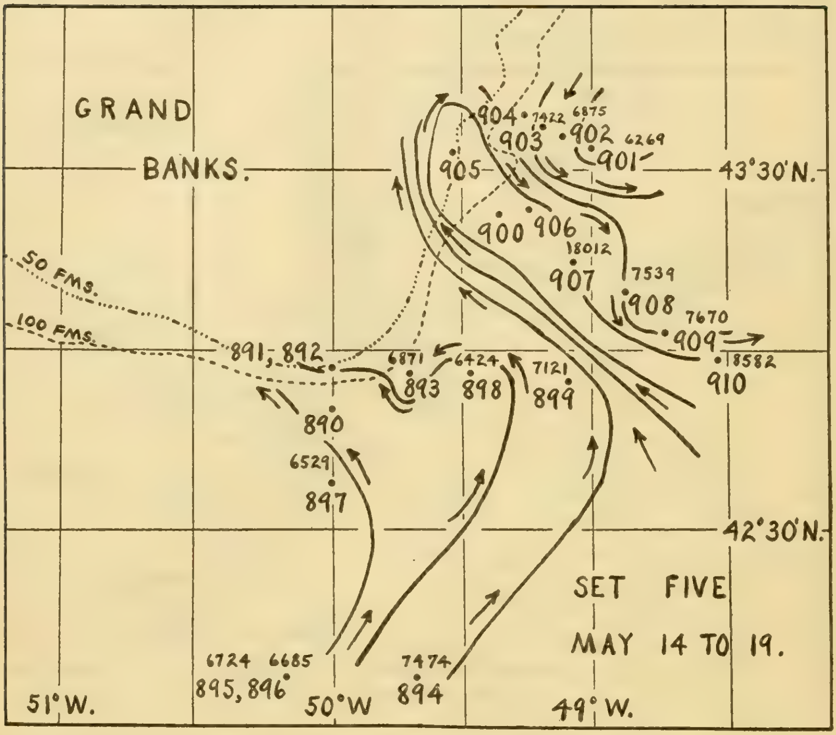

FIGURE 18.—Current map

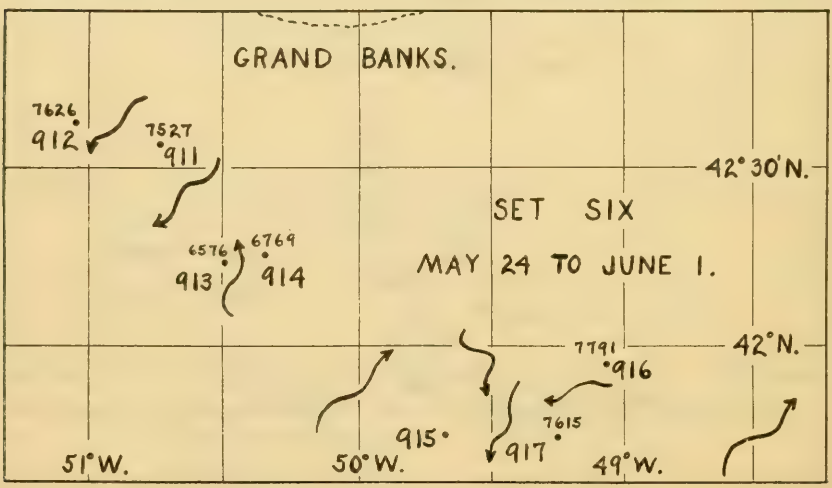

FIGURE 19.—Current tendency diagram

currents flow much like the surface winds do about a barometric anticyclone in the atmosphere, and for the same reasons of gradient gravity pull as modified by earth rotation. The Lows, on the other hand, are actual depressions in the sea surface caused by denser water which is depressed because it is heavier than that surrounding it. Such hollows have counterclockwise currents eddying about them in the northern hemisphere just the same as the barometric cyclones have counterclockwise wind systems about them. In reality the water simply tries to find its own level by slipping down off the Highs and down into the Lows, but it is deflected about 90° by the effect of earth rotation and so spirals around and around them.

The arrows on the current maps show the computed directions of general flow of the local ocean currents and therefore show the probable paths of any bergs that might be located in the vicinity at the time.

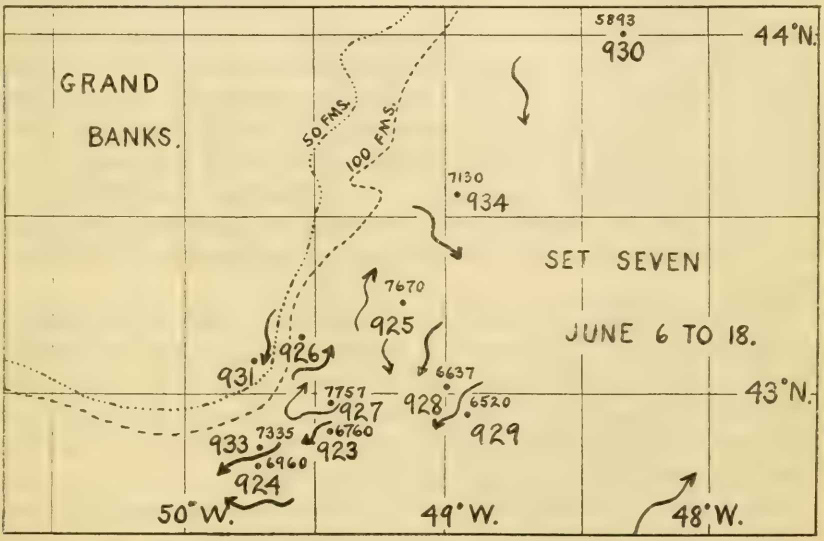

FIGURE 20.—Current tendency diagram

The bergs, being but relatively little influenced by winds and shallow surface drifts, move primarily in accordance with the main gradient circulation of the sea. United States Coast Guard Bulletin 14, A Practical Method for Determining Ocean Currents, was used to make the current maps. That pamphlet explains all the principles involved and then gives explicit directions for working the oceanographic stations and using the results obtained to make the current maps.

Where no four-figure number is given by a station it is because either the depth did not extend down to the 750-decibar level, or if it did, then, due to errors of observations, no reasonable value for the depth of the 750-decibar level below the surface could be computed.

The arrows could be drawn in almost all cases, however, and not just where the 750-decibar levels were computed, for where the latter values were absent higher decibar levels between the stations could be compared.

The station groups when worked out showed densities, and hence current sets and drifts by computation, that were quite logical in all cases when a few stations, obviously in error, were thrown out of the picture. Nothing like an ideal detailed current map could be made, but a number of the stations were so grouped that the width of the cold south-flowing Labrador current was determined at several places and times along the southern half of the eastern edge of the Grand Banks.

The nearest approaches to real current maps made were sets 3 and 5 that are shown in Figures 16 and 18. In these two groups there was enough of a network of stations to permit the construction of dynamic contour lines. These lines actually represent the relief of the average level of the sea surface with wave motion eliminated, and are drawn connecting points that are the same height above a base level that in each case was taken as the deepest sea hollow on the map. When contour lines are drawn in, a much more accurate picture of the oceanic circulation can be formed than where scattered stations, or even good but distantly separated lines of stations at right angles to the Banks, are used.

The currents flow as shown by the arrows in directions parallel to the contour lines. The water, as stated above, always tries to flow down the hill, but there is no outlet at the bottom and earth rotation continually deflects it, so it has to flow along just about parallel to the contours with the higher water on the right hand in the northern hemisphere when facing in the direction of flow.

Sets 3 and 5, studied with and without contour lines, give such radically different pictures of the circulation that it can now be definitely stated that the only distribution of stations that will give results of practical value to the ice patrol is a thick checkerboard network of stations. This is partly on account of the confused eddying conditions in the waters off the Tail of the Grand Banks. In an area where there was less turbulence, where the currents flowed along with less mixing and interaction—as is probably the case farther southwest in the Gulf Stream, and farther north in the Labrador current—a single line of stations taken at right angles to the supposed stream flow would be of value.

The two contoured current maps give just a hint of the complexity and irregularity of the currents that prevail about the Tail of the Banks. The picture of the circulation that would be gained by studying the dynamic relations of the line of stations, as 905 to 910 in one of these figures, would give a simple Labrador current and offshore Gulf Stream

flow and would be misleading instead of useful, in view of the bulb and eddy circulation that actually exists.

Even though scant opportunity was afforded for making station networks, a good many single stations were taken for information and practice, as just before the start of a day's scouting, just after dark when stopping for the night, by a newly found berg, or when stopped by dense fog. These isolated observations gave information about the lower water levels much like that which could be obtained of the underlying strata by scattered borings in a field, the rock conditions under which it was desired to ascertain. The solitary stations could usually be linked together with others not too far distant in space and time to permit the obtaining of fairly reliable and accurate current tendency diagrams.

The three figures—21 to 23—that immediately follow page 74 are the salinity and temperature sections. These have been constructed for the places where lines of stations were taken nearly at right angles to the Grand Banks shelf. The information on which they are based is found in the table of oceanographic station data, but the figures make this information easier to grasp at a glance. In fact the figures show the tendency of the cold fresh water from the north to hug the Bank slope so well that there is no necessity for making detailed comment here.

Following the oceanographic sections come Figures 24 to 30, which are the surface isotherm charts. These were drawn one for each patrol cruise from information on hand at the end of the several 15-day periods. The temperatures on which these maps are based were for the most part sent in from passing vessels, though the patrol vessels themselves on each cruise were able to supplement the surface observations received by radio with their own observations made along their tracks. The temperatures sent in by passing vessels are carefully recorded and analyzed, as they afford the patrol valuable information concerning currents and probable drift of ice.

A tremendous volume of reports made the temperature conditions of the surface waters particularly well recorded in the vicinity of the United States-Europe tracks area. Ships on the Canada-Europe tracks sent in many temperature reports also, but only sparse reports came from the band between these two main traffic lanes.

When the F and B tracks are in use, as they normally are a large part of the ice season, the seldom traversed ocean band between the lanes averages about 300 sea miles wide. Poorly covered for water temperatures means to the patrol poorly covered for ice conditions also. It is this band of ocean intermediate between the great traffic lanes that the ice-patrol vessel regards with much suspicion and to which a great deal of time for scouting for bergs must be given.

Because of its limited location and now well-known tendencies the Labrador current between the steamer lanes could be fairly easily searched for ice by a one-ship-on-duty patrol if good visibility normally prevailed. Unfortunately such is not the case. The cold water about the Banks so projects into the warm ocean that winds from southwest through south to northeast bring warm air to the Labrador current and dense low fogs are produced. The thick weather prevails over the critical blind area such a high percentage of the time during the ice season that great difficulties in successful scouting are experienced. The cold current can not be covered as it really ought to be covered by the patrol. Sometimes the bergs once found are lost during fog and storms and are not located again before they melt entirely.

Therefore, notwithstanding the accumulated experience of the ice patrol and all the advanced scientific methods that have been used, trans-Atlantic traffic even on the southernmost A and B lanes should not depend blindly on the patrol for safety. On the northern lanes the ships fully expect to meet ice at any time when near the Grand Banks, so they are usually quite cautious. The ships on the southern tracks should follow their example during times of fog and darkness. The ice patrol with the information and equipment on hand does all that it is possible for it to do toward locating and keeping track of the ice so that safety along the southern lanes may be assured. In closing this report, however, it is deemed best to sound a note of warning. Shipping is urged to realize the physical limitations of the patrol in its struggle with the obstacles of nature. Steamship companies and captains are requested not to let recent comparative freedom from disaster to lull them into a false sense of security. They must do their part to insure safety while crossing the probable ice area by exercising sound judgement, reducing speed, and being cautious during all times of low visibility, even when the patrol's broadcasts indicate that they are well clear of all known ice.

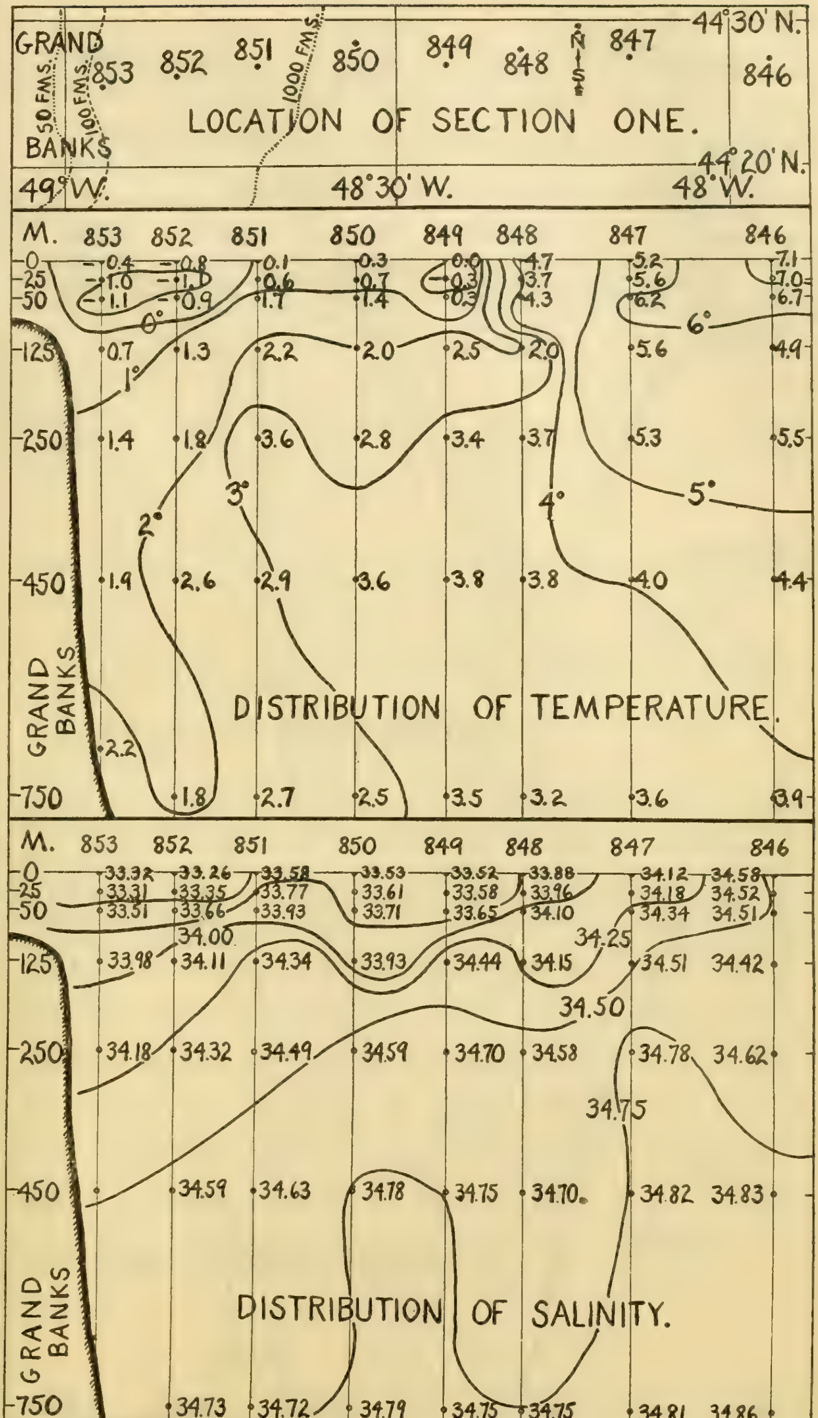

FIGURE 21.—Oceanographic section one was drawn from data obtained from stations taken on April 2, 1928, off the east slope of the Grand Banks. Depths are in meters. Temperatures are in degrees centigrade. Salinities are shown in total parts all salts per thousand parts sea water.

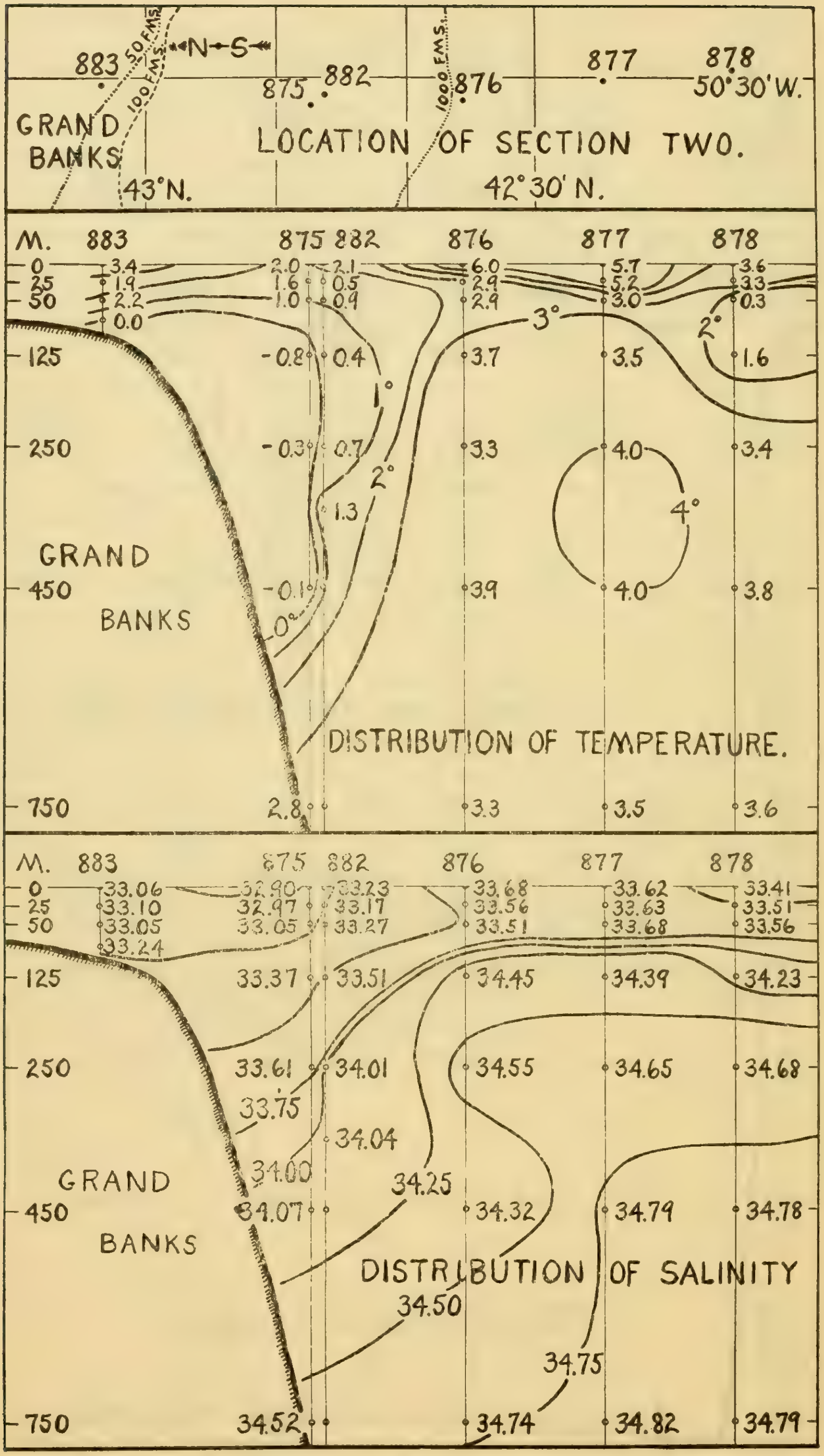

FIGURE 22.—Oceanographic section two. Off south slope of the Grand Banks. Stations occupied April 29 to May 3, 1928

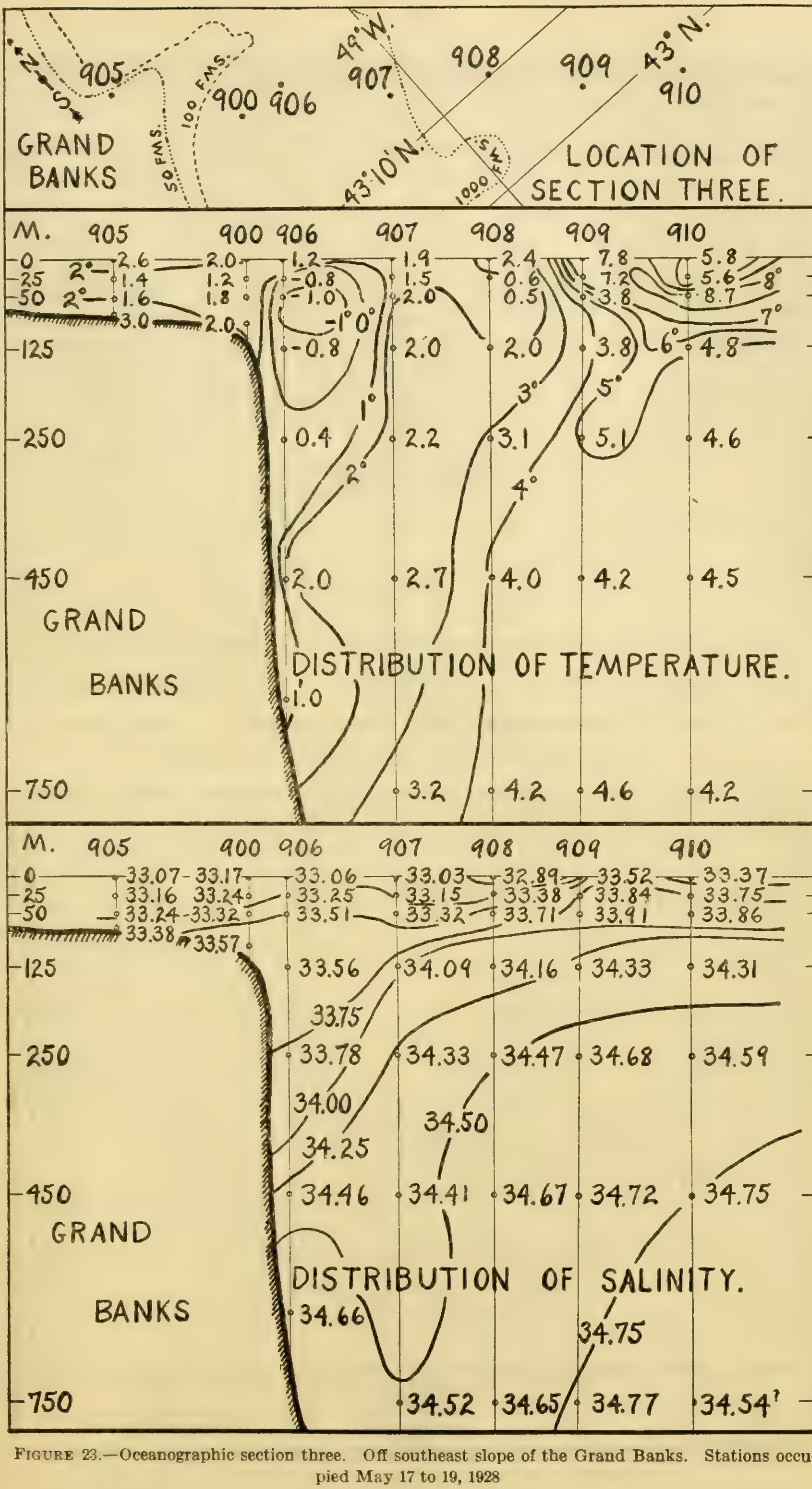

FIGURE 23.—Oceanographic section three. Off southeast slope of the Grand Banks. Stations occupied May 17 to 19, 1928

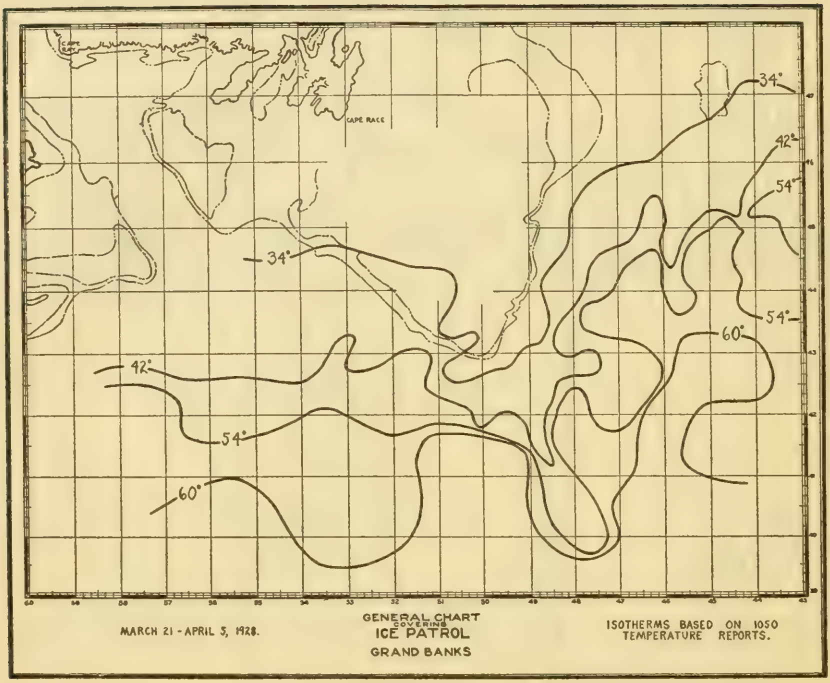

FIGURE 24.—Surface temperatures March 21 to April 5, 1928

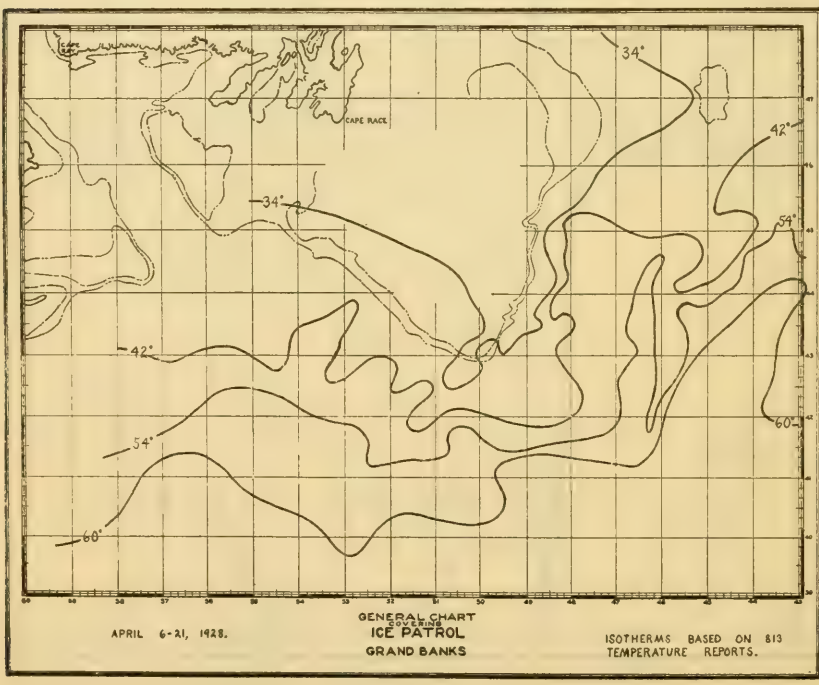

FIGURE 25.—Surface temperatures April 6 to 21, 1928

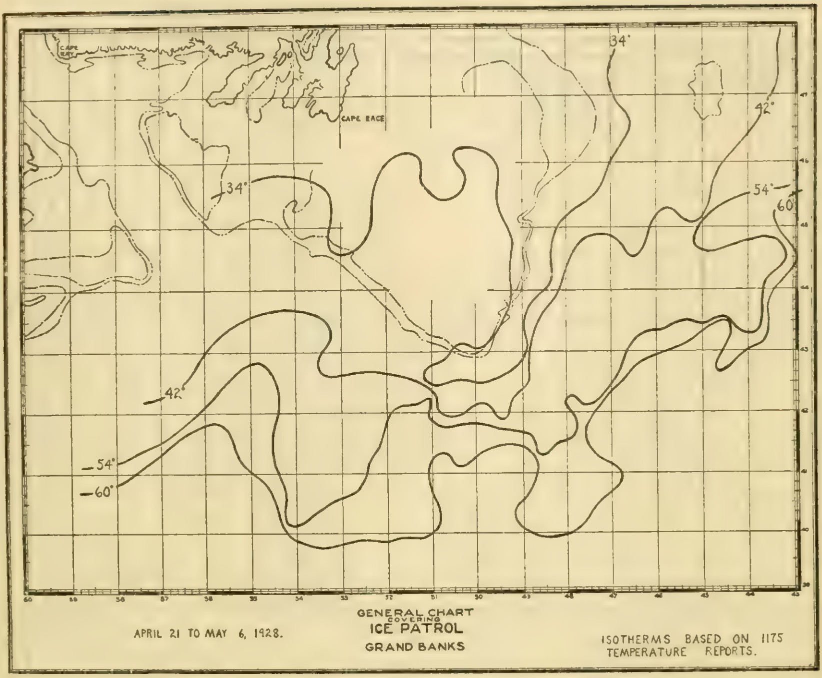

FIGURE 26.—Surface temperatures April 21 to May 6, 1928

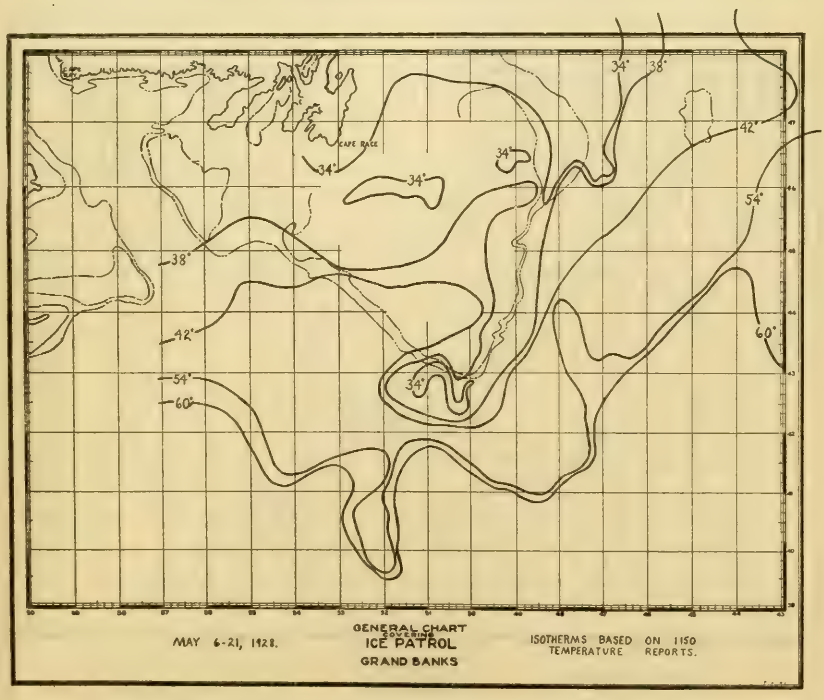

FIGURE 27.—Surface temperatures May 6 to 21, 1928

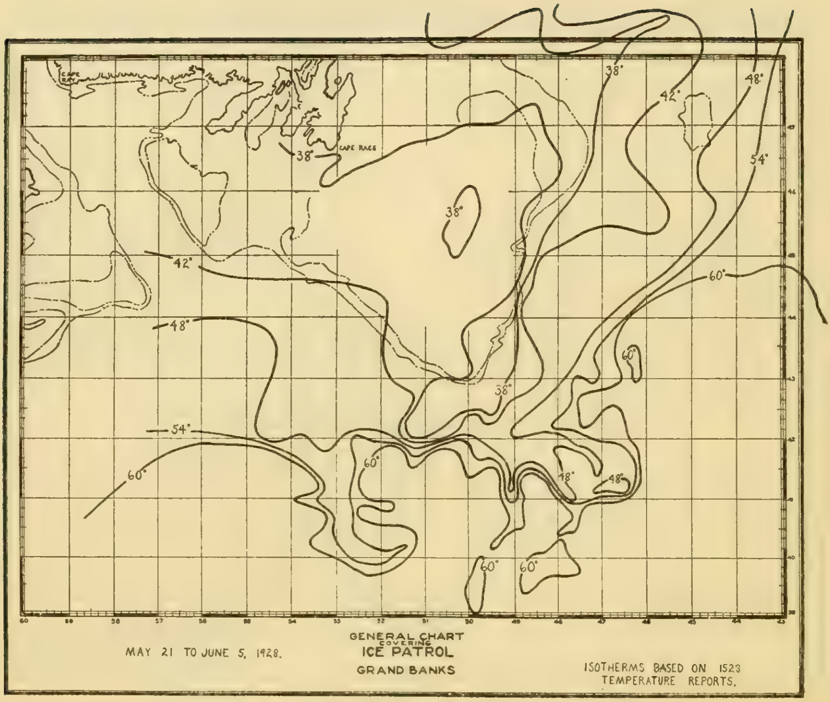

FIGURE 28. Surface temperatures May 21 to June 5, 1928

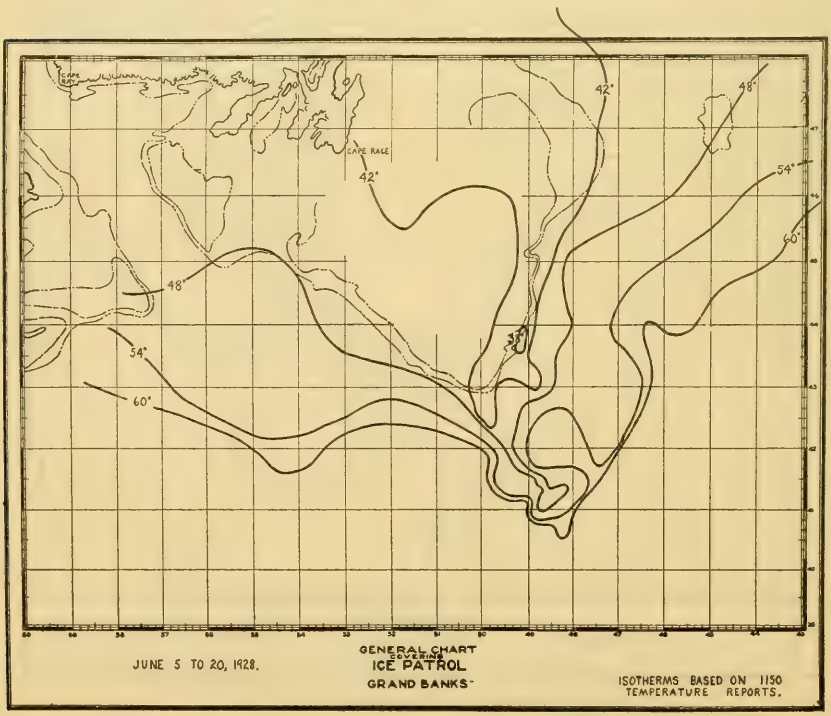

FIGURE 29.—Surface temperatures June 5 to 20, 1928

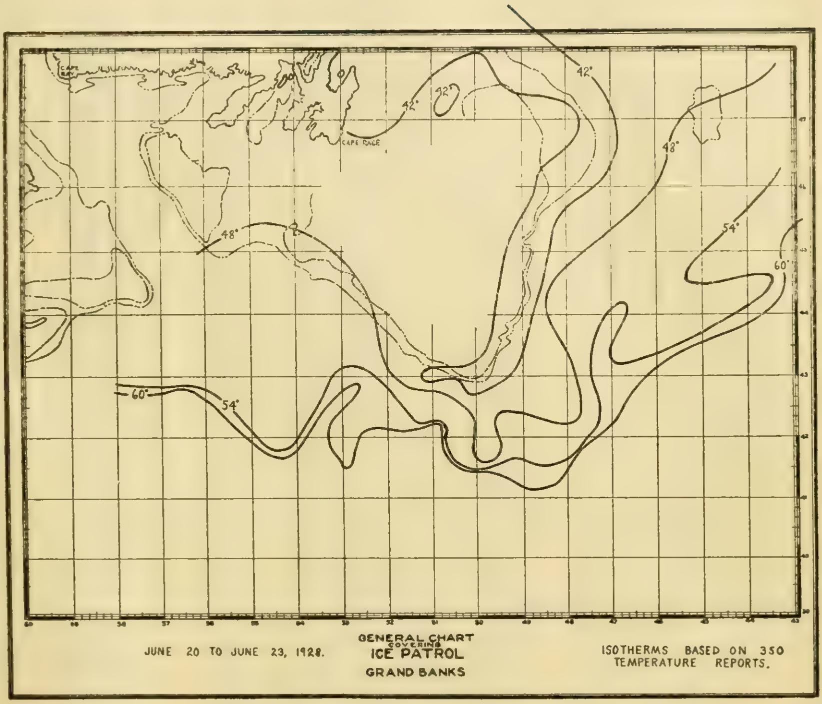

FIGURE 30.—Surface temperatures June 20 to 23, 1928

OCEANOGRAPHIC STATION DATA AND DYNAMIC CALCULATIONS, 1928

δ_t at head of column 9 represents the value, density.
V at head of column 10 represents the value, specific volume in situ.
$V-V_1$ at head of column 11 represents the value, anomaly of specific volume in situ.
E at head of column 12 represents the value, height in dynamic meters.
$E-E_1$ at head of column 13 represents the value, anomaly of dynamic height.

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	$V-V_1$	E	$E-E_1$
		° ′	° ′	*Meters*		°*C.*	‰					
840	Mar. 26	43 15	49 52	62	0	0.1	33.35	26.79	0.97391	127	0	0
					10	.0	33.27	26.73	.97391	131	9.73910	.01290
					20	.0	33.29	26.75	.97385	130	19.47790	.02595
					30	.0	33.24	26.71	.97384	134	29.21635	.03910
					40	−.1	33.28	26.75	.97375	129	38.95430	.05220
					50	.1	33.24	26.71	.97375	133	48.69180	.06530
841	---do----	43 10	49 42	120	0	−.5	33.42	26.87	.97383	119	0	0
					10	−.6	33.46	26.91	.97374	114	9.73785	.01165
					25	−.6	33.41	26.87	.97372	119	24.34380	.02915
					50	−.6	33.47	26.92	.97355	113	48.68467	.05817
					75	−.6	33.48	26.93	.97343	112	73.02192	.08638
					100	−.6	33.58	27.01	.97325	106	97.35542	.11367
842	---do----	43 03	49 32	411	0	−.2	33.37	26.82	.97388	124	0	0
					25	−.8	33.64	27.06	.97355	102	24.34285	.02820
					50	−.8	33.55	26.98	.97350	108	48.68097	.05447
					125	−.8	34.01	27.36	.97281	73	121.66760	.12248
					250	−.2	33.95	27.29	.97232	80	243.23821	.21822
					450	−.8	34.34	27.63	.97108	46	437.57871	.34472
843	---do----	42 57	49 21	1,628	0	−.8	33.45	26.92	.97378	114	0	0
					25	−1.0	33.45	26.92	.97367	114	24.34312	.02847
					50	−1.0	33.51	26.97	.97351	109	48.68287	.05637
					125	.2	33.81	27.16	.97300	92	121.67699	.13187
					250	1.8	33.39	27.52	.97211	59	243.24636	.22637
					450	2.8	34.61	27.62	.97113	51	437.57036	.33687
					750	.5	34.73	27.88	.96953	24	728.66936	.44987
844	Mar. 28	43 24	49 16	164	0	−.8	33.29	26.78	.97392	128	0	0
					10	−.8	33.32	26.80	.97385	125	9.73885	.01145
					25	−1.0	33.34	26.83	.97376	123	24.34592	.03027
					50	−1.0	33.34	26.83	.97364	122	48.68717	.06067
					75	−1.1	33.37	26.86	.97350	119	73.02642	.09088
					100	−1.1	33.37	26.86	.97339	120	97.36254	.11097
					150	−1.0	33.48	26.94	.97308	111	146.02429	.17855
845	---do----	43 32	49 37	60	0	.7	33.01	26.48	.97420	156	0	0
					10	.7	33.01	26.48	.97415	155	9.74175	.01555
					20	.4	33.09	26.57	.97403	148	19.48265	.03070
					30	.3	33.09	26.57	.97398	147	29.22270	.04535
					40	.3	33.09	26.57	.97393	147	38.96225	.06015
					50	.3	33.09	26.57	.97389	147	48.70135	.07485
846	Apr. 2	44 26	47 56	3,567	0	7.1	34.58	27.10	.97362	98	0	0
					25	7.0	34.52	27.07	.97354	101	24.33950	.01485
					50	6.7	[1] 34.51	[1] 27.10	.97340	98	48.67625	.04975
					125	4.9	34.42	27.25	.97292	84	121.66325	.11813
					250	5.5	34.62	27.34	.97230	78	243.23762	.21763
					450	4.4	34.83	27.63	.97113	51	437.58062	.34713
					750	3.9	34.86	27.71	.96975	46	728.71262	.49313
847	---do----	44 26	48 09	3,475	0	5.2	34.12	26.98	.97373	109	0	0
					25	5.6	34.18	26.98	.97362	109	24.34187	.02485
					50	6.2	34.34	27.03	.97346	104	48.68037	.05387
					125	5.6	34.51	27.34	.97295	87	121.66699	.12187
					250	5.3	34.78	27.49	.97217	65	243.23074	.22075
					450	4.0	34.82	27.67	.97110	48	437.55774	.32425
					750	3.6	34.81	27.70	.96975	46	728.68524	.46575
848	---do----	44 27	48 19	3,274	0	4.7	33.88	26.85	.97385	121	0	0
					25	3.7	33.96	27.00	.97359	106	24.34300	.03835
					50	4.3	34.10	27.06	.97343	101	48.68075	.05425
					125	2.0	34.15	27.31	.97287	79	121.66700	.12188
					250	3.7	34.58	27.50	.97214	62	243.23012	.21013
					450	3.8	34.70	27.59	.97117	55	437.56112	.32763
					750	3.2	34.75	27.69	.96975	46	728.69912	.47963
849	---do----	44 27	48 26	2,972	0	.0	33.52	26.93	.97377	113	0	0
					25	−.3	33.58	27.00	.97360	107	24.34212	.02747
					50	.3	33.65	27.02	.97346	104	48.67987	.05337
					125	2.5	34.44	27.50	.97269	61	121.66049	.11537
					250	3.4	34.70	27.63	.97200	48	243.20361	.18362
					450	3.8	34.75	27.61	.97115	53	437.51861	.28492
					750	3.5	34.75	27.66	.96979	50	728.65961	.44012
850	---do----	44 28	48 34	2,332	0	.3	33.53	26.93	.97377	113	0	0
					25	.7	33.61	26.97	.97363	110	24.34250	.02785
					50	1.4	33.71	27.00	.97348	106	48.68137	.05487
					125	2.0	33.93	27.14	.97303	95	121.67549	.13037
					250	2.8	34.59	27.60	.97203	51	243.24174	.22175
					450	3.6	34.78	27.67	.97110	48	437.55474	.32105
					750	2.5	34.79	27.78	.96966	37	728.66874	.44925

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	V−V₁	E	E−E₁
		° ′	° ′	*Meters*		°*C.*	‰					
851	Apr. 2	44 27	48 42	2,241	0	.1	33.58	26.98	0.97373	109	0	0
					25	.6	33.77	27.10	.97351	98	24.34050	.02585
					50	1.7	33.93	27.16	.97333	91	48.67600	.04950
					125	2.2	34.34	27.45	.97273	65	121.65325	.10813
					250	3.6	34.49	27.44	.97219	67	243.21075	.19076
					450	2.9	34.63	27.62	.97113	51	437.54275	.30906
					750	2.7	34.72	27.71	.96973	44	728.67175	.45226
852	---do----	44 26	48 50	1,875	0	−.8	33.26	26.76	.97394	130	0	0
					25	−1.1	33.35	26.84	.97375	122	24.34612	.03147
					50	−.9	33.66	27.08	.97341	99	48.68562	.05912
					125	1.3	34.11	27.33	.97284	76	121.70749	.16237
					250	1.8	34.32	27.46	.97217	65	243.27061	.25062
					450	2.6	34.59	27.61	.97114	52	437.60161	.36792
					750	1.8	34.73	27.79	.96964	35	728.71861	.49912
853	---do----	44 26	48 57	731	0	−.4	33.32	26.79	.97391	127	0	0
					25	−1.0	33.31	26.80	.97378	125	24.34625	.03160
					50	−1.1	33.51	26.97	.97351	109	48.68750	.06100
					125	.7	33.98	27.27	.97290	82	121.67787	.13275
					250	1.4	34.18	27.38	.97224	72	243.24912	.22913
854	Apr. 3	44 15	48 58	153	0	−1.0	33.35	26.84	.97386	122	0	0
					10	−1.1	33.36	26.85	.97380	120	9.73830	.01210
					25	−1.1	33.32	26.81	.97378	125	24.34515	.03050
					50	−1.4	33.38	26.87	.97360	118	48.68740	.06090
					75	−1.2	33.41	26.89	.97347	116	73.02577	.09023
					125	−.9	33.57	27.01	.97314	106	121.69102	.14590
855	Apr. 9	44 23	48 15	2,926	0	.3	33.64	27.01	.97370	106	0	0
					25	.3	33.51	26.91	.97368	115	24.34225	.02760
					50	.2	33.61	26.99	.97349	107	48.68187	.05537
					125	1.6	34.37	27.52	.97267	59	121.66287	.11775
					250	3.0	34.52	27.53	.97210	58	242.21099	.19100
					450	3.2	34.63	27.60	.97115	53	437.53699	.30350
					750	3.2	34.70	27.65	.96979	50	728.67799	45850
856	---do----	44 24	48 12	3,265	0	1 4	33.64	26.94	.97376	112	0	0
					25	1.2	33.75	27.05	.97355	102	24.34137	.02672
					50	1.9	34.11	27.29	.97321	79	48.67587	.04937
					125	3.3	34.52	27.50	.97269	61	121.64712	.10200
					250	3.0	34.61	27.60	.97203	51	243.19212	.17213
					450	2.9	34.56	27.57	.97118	56	437.51312	.27963
					750	3.3	34.68	27.62	.96982	53	728.66312	.44363
857	---do----	44 25	48 26	2,469	0	−.2	33.00	26.52	.97416	152	0	0
					25	−.7	33.49	26.94	.97365	112	24.34762	.03297
					50	−.4	33.84	27.21	.97328	86	48.68424	.05774
					125	−.3	34.34	27.61	.97257	49	121.65361	.10849
					250	3.6	34.68	27.59	.97204	52	243.19173	.17174
					450	3.0	34.54	27.54	.97121	59	437.51673	.28324
					750	3.2	34.70	27.65	.96979	50	728.66673	.44724
858	---do----	44 26	48 40	1,829	0	−.5	[2] 33.84	[1] 26.78	.97392	128	0	0
					25	−.9	33.29	26.78	.97381	128	24.34662	.03197
					50	.1	33.37	26.80	.97367	125	48.69012	.06362
					125	.1	34.01	27.32	.97285	77	121.68462	.13950
					250	1.6	34.42	27.56	.97207	55	243.24212	.22213
					450	2.7	34.54	27.57	.97118	56	437.56712	.33363
					750	3.1	34.64	27.61	.96982	53	728.71712	.49763
859	Apr. 14	44 40	46 00	3,658	0	4.2	34.00	27.00	.97371	107	0	0
					25	4.0	34.01	27.03	.97357	104	24.34100	.02635
					50	3.7	34.06	27.09	.97340	98	48.67812	.05162
					125	5.9	34.56	27.24	.97294	86	121.66587	.12075
					250	4.4	34.67	27.50	.97214	62	243.23337	.21338
					450	5.0	34.80	27.54	.97123	61	437.57037	.33688
					750	5.6	34.86	27.53	.96995	66	728.74737	.52788
860	Apr. 15	45 03	48 22	2,012	0	1.5	33.90	27.15	.97357	93	0	0
					25	1.1	33.96	27.23	.97338	85	24.33685	.02220
					50	2.5	34.44	27.50	.97301	59	48.66672	.04022
					125	3.5	34.54	27.49	.97270	62	121.63084	.08572
					250	3.8	34.63	27.53	.97211	59	243.18146	.16147
					450	2.9	34.59	27.67	.97109	47	437.50146	.26797
					750	3.2	34.71	27.66	.96978	49	728.63196	.41247
861	Apr. 16	44 53	48 44	1,829	0	−.6	33.40	26.86	.97384	120	0	0
					25	−.3	33.50	26.93	.97366	113	24.34375	.02910
					50	−.2	33.66	27.06	.97343	101	48.68237	.05587
					125	−.4	33.89	27.25	.97291	83	121.67012	.12500
					250	2.2	34.29	27.40	.97222	70	243.24074	.22075
					450	[1] 3.2	34.63	27.56	.97119	57	437.58174	.34825
					750	3.2	34.65	27.61	.96981	52	728.73174	.51225

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.
[2] Values obviously in error, but included for completeness and to show what was actually recorded.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	V−V₁	E	E−E₁
		° ′	° ′	*Meters*		°*C.*	‰					
862	Apr. 16	44 56	48 54	350	0	−.8	33.11	26.63	0.97406	142	0	0
					25	−1.0	33.16	26.68	.97390	137	24.34950	.03485
					50	−1.2	33.19	26.71	.97375	133	48.67012	.04362
					125	−1.2	33.22	26.73	.97340	132	121.68824	.14312
					200	−1.1	33.61	27.00	.97280	106	194.67074	.23225
					250	.7	33.81	27.14	.97247	95	243.30249	.28250
					300	1.2	33.91	27.18	.97220	91	291.91924	.32186
863	---do----	44 58	49 04	60	0	−.8	33.12	26.64	.97405	141	0	0
					10	−.7	33.02	26.56	.97408	148	9.74065	.01445
					25	1.1	33.17	26.59	.97399	146	24.35167	.03702
					50	−1.0	33.17	26.69	.97377	124	48.69817	.07167
864	Apr. 18	43 44	48 37	2,926	0	.7	33.59	27.02	.97369	105	0	0
					25	.6	33.81	27.14	.97347	94	24.33950	.02485
					50	.8	33.96	27.25	.97325	83	48.67350	.04700
					125	2.8	34.37	27.42	.97276	68	121.64887	.10375
					250	2.8	34.49	27.52	.97211	59	243.20324	.18325
					450	2.8	34.68	27.67	.97109	47	437.52324	.28975
					750	3.2	34.68	27.64	.96979	50	728.65524	.43575
865	Apr. 20	43 07	49 42	225	0	−.8	33.22	26.72	.97397	133	0	0
					25	−.8	33.17	26.68	.97390	137	24.34837	.03372
					50	−1.0	33.32	26.81	.97366	124	48.69287	.06637
					125	−1.0	33.49	26.95	.97319	111	121.69974	.15462
					200	−.6	33.81	27.19	.97262	88	194.66761	.22912
866	---do----	43 06	49 56	60	0	.1	33.20	26.67	.97402	138	0	0
					25	.2	33.22	26.67	.97391	138	24.34912	.03447
					50	[1] −.4	33.23	26.71	.97375	133	48.69487	.06837
					60	−.5	33.26	26.74	.97368	131	58.43202	.08157
867	---do----	42 55	49 56	225	0	−.3	33.21	26.69	.97400	136	0	0
					25	−.5	33.25	26.74	.97384	131	24.34800	.03335
					50	−1.1	33.31	26.81	.97366	124	48.69175	.06525
					125	−1.2	33.41	26.89	.97325	111	121.70087	.15575
					200	−1.1	33.49	26.96	.97284	110	194.67924	.14075
868	---do-----	42 45	49 56	915	0	−.3	33.12	26.62	.97407	143	0	0
					25	−.6	33.24	26.74	.97384	131	24.34887	.03422
					50	−.6	33.31	26.79	.97368	126	48.69287	.06637
					125	1.3	34.09	27.32	.97285	77	121.68774	.14262
					250	2.6	34.52	27.56	.97207	55	243.24524	.22525
					450	3.0	34.73	27.65	.97106	44	437.55724	.32375
					750	3.2	34.70	27.70	.96978	49	728.68424	.46475
869	Apr. 23	42 46	49 18	2,012	0	1.2	33.22	26.62	.97407	143	0	0
					25	1.9	33.51	26.80	.97379	126	24.34875	.03210
					50	1.8	34.11	27.29	.97321	79	48.68575	.05925
					125	3.4	34.59	27.54	.97265	57	121.65550	.11038
					250	3.4	34.63	27.57	.97206	54	243.19987	.17988
					450	3.8	34.77	27.65	.97111	49	437.51687	.28338
					750	3.8	34.81	27.68	.96978	49	728.65037	.43088
870	Apr. 24	42 43	49 19	1,326	0	3.6	33.58	26.81	.97389	125	0	0
					25	1.2	33.64	26.96	.97364	111	24.34412	.02947
					50	1.2	33.74	27.04	.97344	102	48.68262	.05612
					125	3.1	34.55	27.54	.97265	57	121.66099	.11587
					250	2.6	34.64	27.65	.97199	47	243.20099	.18100
					450	3.0	34.68	27.65	.97111	49	437.51099	.27750
					750	3.4	34.73	27.65	.96980	51	728.64749	.42800
871	Apr. 25	42 51	49 40	1,372	0	1.3	33.30	26.67	.97402	138	0	0
					25	.2	33.32	26.76	.97382	129	24.34800	.03335
					50	−.9	33.53	26.94	.97351	109	48.68962	.06312
					125	−.8	34.52	26.97	.97318	110	121.69049	.14537
					250	2.0	34.39	27.50	.97213	61	243.27237	.25238
					450	2.9	34.59	27.59	.97116	54	437.60137	.36788
					750	3.0	34.73	27.70	.96974	45	728.73637	.51688
872	---do-----	42 49	49 07	2,058	0	3.2	33.61	26.78	.97392	128	0	0
					25	2.0	33.64	26.90	.97369	116	24.34512	.03047
					50	1.8	33.71	26.97	.97351	109	48.68512	.05862
					125	2.8	34.26	27.34	.97284	76	121.67324	.12812
					250	5.0	34.73	27.49	.97215	63	243.23511	.21512
					450	3.2	34.73	27.68	.97108	46	437.55811	.32462
					750	3.6	34.81	27.70	.96975	46	728.68261	.46312
873	---do-----	42 34	49 29	2,332	0	5.0	33.59	26.58	.97411	147	0	0
					25	4.2	33.66	26.72	.97386	133	24.34962	.03497
					50	2.9	33.92	27.06	.97343	101	48.69074	.06424
					125	3.3	34.25	27.28	.97290	82	121.67811	.13299
					250	4.1	34.50	27.40	.97223	71	243.24873	.22874
					450	4.1	34.73	27.58	.97118	56	437.58973	.35624
					750	3.7	34.81	27.64	.96976	47	728.73073	.51124
874	Apr. 27	42 50	50 09	263	0	2.2	33.25	26.58	.97411	147	0	0
					25	−.4	33.21	26.66	.97392	139	24.35037	.03572
					50	−.6	[1] 33.26	[1] 26.75	.97371	129	48.69574	.06924
					125	−.8	33.52	26.96	.97319	111	121.70449	.15937
					250	1.0	34.21	27.43	.97219	67	243.29074	.27075

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	V−V₁	E	E−E₁
		° ′	° ′	*Meters*		°*C.*	‰					
875	Apr. 29	42 47	50 32	1,052	0	2.0	32.90	26.31	0.97436	172	0	0
					25	1.6	32.97	26.39	.97418	165	24.35675	.04210
					50	1.0	[1] 33.05	26.50	.97395	153	48.70837	.08187
					125	−.8	33.37	26.84	.97330	122	121.73024	.18512
					250	−.3	33.61	27.02	.97258	105	243.34774	.32775
					450	−.1	34.07	27.28	.97143	81	437.74874	.51525
					750	2.8	34.52	27.54	.96989	60	728.94674	.72725
876	...do.....	42 36	50 32	2,012	0	6.0	33.68	26.53	.97415	151	0	0
					25	2.9	33.56	[2] 26.77	.97382	129	24.34962	.03497
					50	2.9	33.51	26.73	.97373	131	48.69399	.06749
					125	3.7	34.45	27.40	.97278	70	121.68811	.14299
					250	3.3	34.55	27.52	.97211	59	243.24373	.22374
					450	3.9	34.32	[2] 27.28	.97247	185	437.70173	.46824
					750	3.3	34.74	27.67	.96978	49	729.03923	.81974
877	...do.....	42 25	50 30	2,643	0	5.7	33.62	26.52	.97416	152	0	0
					25	[1] 5.2	33.63	26.59	.97399	146	24.35187	.03722
					50	3.0	33.68	26.85	.97362	120	48.69699	.07049
					125	3.5	34.39	27.37	.97281	73	121.68811	.14299
					250	4.0	34.65	27.53	.97211	59	243.24561	.22562
					450	4.0	34.79	27.64	.97112	50	437.56861	.33512
					750	3.5	34.82	27.72	.96973	44	728.69611	.47662
878	...do.....	42 15	50 30	3,000	0	3.6	33.41	26.58	.97411	147	0	0
					25	3.3	33.51	26.69	.97389	136	24.35000	.03535
					50	.3	33.56	26.95	.97352	110	48.69262	.06612
					125	1.6	34.23	27.40	.97278	70	121.67887	.13375
					250	3.4	34.68	27.62	.97201	49	243.22824	.20825
					450	3.8	34.78	27.66	.97111	49	437.54024	.30675
					750	3.6	34.79	27.68	.96977	48	728.67224	.45275
879	May 1	43 07	50 04	60	0	2.9	33.04	26.35	.97432	168	0	0
					25	1.9	33.23	26.58	.97400	147	24.35400	.03935
					50	.0	33.20	26.68	.97378	136	48.70125	.07475
					60	.2	33.22	26.68	.97374	137	58.43885	.08840
880	...do.....	43 00	49 51	180	0	1.4	33.22	26.61	.97408	144	0	0
					25	.5	33.23	26.67	.97391	138	24.34987	.03522
					50	−.4	33.22	26.71	.97375	133	48.69562	.06912
					125	−.6	33.34	26.81	.97333	125	121.71112	.16600
					175	−.7	33.46	26.91	.97300	115	170.36937	--------
881	May 2	42 52	49 52	732	0	1.1	33.12	26.55	.97413	149	0	0
					25	.6	33.12	26.57	.97401	148	24.35175	.03710
					50	−.2	33.27	26.74	.97372	130	48.69837	.07187
					125	−.2	33.51	26.93	.97321	113	121.70824	.16312
					250	1.2	34.08	27.31	.97231	79	243.30324	.28325
					450	2.5	34.51	27.56	.97119	57	437.65324	.41975
					750	2.8	34.54	27.56	.96987	58	728.81224	.59275
882	...do.....	42 46	50 31	350	0	2.1	33.23	26.56	.97413	149	0	0
					25	.5	33.17	26.62	.97396	143	24.35112	.03647
					50	−.9	33.27	26.77	.97370	128	48.69687	.07037
					125	−.4	33.51	26.94	.97320	112	121.70562	.16050
					250	.7	34.01	27.29	.97233	81	243.30124	.28125
					325	1.3	34.04	27.28	.97200	82	316.21361	--------
883	May 3	43 04	50 31	93	0	3.4	33.06	26.43	.97425	161	0	0
					25	1.9	33.10	26.48	.97409	156	24.35425	.03960
					50	2.2	33.05	26.41	.97404	162	48.70587	.07937
					75	0	33.24	26.71	.97364	133	73.05187	.11633
884	May 7	42 12	49 50	3,109	0	6.5	34.04	26.75	.97394	130	0	0
					25	6.4	34.07	26.79	.97380	127	24.34675	.03210
					50	6.4	34.07	26.79	.97369	127	48.69037	.06387
					125	5.0	34.42	27.24	.97293	85	121.68862	.14350
					250	3.4	34.72	27.65	.97198	46	243.24549	.22550
					450	4.8	34.71	27.48	.97129	67	437.55249	.31900
					750	3.7	34.93	27.78	.96967	38	728.69649	.47700
885	...do.....	42 22	49 43	3,246	0	6.6	34.19	26.86	.97384	120	0	0
					25	6.4	34.23	26.92	.97367	114	24.34387	.02922
					50	6.4	34.20	26.89	.97359	117	48.68462	.05812
					125	6.2	34.63	27.26	.97293	85	121.67912	.13400
					250	3.8	34.72	27.61	.97203	51	243.23912	.21913
					450	4.7	34.86	27.62	.97115	53	437.55712	.32363
					750	4.9	34.77	27.53	.96994	65	728.72062	.50113
886	...do.....	42 14	50 12	3,292	0	4.4	33.75	26.77	.97393	129	0	0
					25	4.0	33.76	26.83	.97376	123	24.34612	.03147
					50	4.0	33.77	26.83	.97364	122	48.68862	.06212
					125	2.8	34.31	27.37	.97281	73	121.68049	.13537
					250	3.5	34.61	27.55	.97209	57	243.23674	.21675
					450	4.2	34.89	27.70	.97107	45	437.55274	.31925
					750	3.8	35.02	27.85	.96961	32	728.65474	.43525

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.
[2] Values obviously in error, but included for completeness and to show what was actually recorded.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	$V-V_1$	E	$E-E_1$
		° ′	° ′	*Meters*		°*C.*	‰					
887	May 9	42 36	49 35	2,561	0	3.6	33.58	26.72	0.97397	133	0	0
					25	2.6	33.65	26.86	.97373	120	24.34625	.03160
					50	1.9	33.81	27.05	.97343	101	48.68575	.05925
					125	2.5	34.40	27.46	.97273	65	121.66675	.12163
					250	3.7	34.80	27.68	.97197	45	243.21050	.19051
					450	4.0	34.84	27.68	.97109	47	437.51650	.28301
					750	4.2	34.88	27.69	.96977	48	728.64550	.42601
888	May 10	41 55	50 00	3,475	0	2.9	33.41	26.65	.97404	140	0	0
					25	3.6	33.56	26.70	.97388	135	24.34900	.03435
					50	1.9	33.63	26.90	.97357	115	48.69212	.06562
					125	3.9	34.24	27.21	.97296	88	121.68699	.14187
					250	4.5	34.80	27.60	.97204	52	243.24949	.22950
					450	4.1	34.87	27.69	.97108	46	437.56149	.32800
					750	6.4	33.45	26.30	.97112	183	728.89149	.67200
889	May 11	42 00	49 50	3,292	0	7.1	33.90	26.57	.97412	148	0	0
					25	5.2	33.53	26.51	.97406	153	24.35225	.03760
					50	5.7	34.32	27.07	.97343	101	48.69587	.06937
					125	3.4	34.02	27.10	.97307	99	121.68962	.14450
					250	4.5	34.78	27.58	.97207	55	243.26087	.24088
					450	4.2	34.88	27.69	.97108	46	437.57587	.34238
					750	4.5	34.90	27.68	.96979	50	728.70637	.48688
890	May 14	42 51	50 00	275	0	2.3	33.19	26.52	.97416	152	0	0
					25	.0	33.30	26.75	.97383	130	24.34987	.03522
					50	−1.0	33.38	26.86	.97361	119	48.69287	.06637
					125	−.4	33.66	27.08	.97308	100	121.69374	.14862
					200	.4	33.60	26.96	.97285	111	194.66611	.22762
					250	1.8	34.18	27 35	97227	75	243 29411	27412
891	---do----	42 57	50 00	175	0	2.0	33.18	26.53	.97415	151	0	0
					25	.9	33.21	26.63	.97395	142	24.35125	.03660
					100	−.8	33.43	26.89	.97336	117	97.37537	.13362
					175	−.7	33.65	27.08	.97285	100	170.35824	--------
892	---do----	42 57	50 00	175	0	2.0	33.19	26.54	.97414	150	0	0
					25	1.2	33.34	26.72	.97386	133	24.35000	.03535
					50	.4	33.24	26.68	.97378	136	48.69550	.06900
					125	−.9	33.61	27.04	.97311	103	121.70387	.15875
					175	−.3	33.43	26.87	.97304	119	170.35762	--------
893	---do----	42 57	49 42	915	0	2.0	33.20	26.55	.97413	149	0	0
					25	.6	33.32	26.74	.97384	131	24.34962	.03497
					50	.0	33.39	26.83	.97364	122	48.69312	.06662
					125	.8	33.86	27.17	.97299	91	121.69174	.14662
					250	2.5	34.66	27.68	.97196	44	243.25111	.23112
					450	3.0	34.55	27.55	.97120	58	437.56711	.33362
					750	2.8	34.89	27.84	.96960	31	728.68711	.46762
894	May 15	42 05	49 41	3,292	0	8.0	33.91	26.44	.97424	160	0	0
					25	5.6	33.76	26.64	.97394	141	24.35225	.03760
					50	2.8	33.81	26.97	.97351	109	48.69537	.06887
					125	4.8	34.52	27.34	.97284	76	121.68349	.13837
					250	4.8	34.68	27.46	.97219	67	243.24786	.22787
					450	4.1	34.66	27.53	.97123	61	437.58986	.35637
					750	4.6	34.87	27.64	.96982	53	728.74736	.52787
895	May 16	42 05	50 10	3,475	0	2.8	33.26	26.53	.97415	151	0	0
					25	1.0	33.44	26.81	.97378	125	24.34912	.03447
					50	1.0	33.83	27.13	.97336	94	48.68837	.06187
					125	1.6	34.22	27.40	.97278	72	121.66862	.12350
					250	3.2	34.28	27.56	.97207	55	243.22174	.20175
					450	4.0	34.84	27.68	.97109	47	437.53774	.30425
					750	3.5	34.84	27.73	.96982	53	728.67424	.45475
896	---do----	42 05	50 10	3,475	0	2.8	33.26	26.53	.97415	151	0	0
					25	1.4	33.36	26.72	.97386	133	24.35012	.03547
					50	1.2	33.96	27.22	.97327	85	48.68924	.06274
					125	2.2	34.37	27.47	.97272	64	121.66386	.11874
					250	4.0	34.58	27.47	.97217	65	243.21948	.19949
					450	4.0	34.84	27.68	.97109	47	437.54548	.31199
					750	3.6	34.84	27.72	.96973	44	728.66848	.44899
897	---do----	42 38	50 00	1,829	0	3.2	33.50	26.69	.97400	136	0	0
					25	2.8	33.54	26.84	.97375	122	24.34687	.03222
					50	1.8	33.73	26.99	.97349	107	48.68737	.06087
					125	2.2	34.32	27.43	.97275	67	121.67137	.12625
					250	2.7	34.55	27.58	.97205	53	243.22137	.20138
					450	3.0	34.66	27.64	.97111	49	437.53737	.30388
					750	2.6	34.79	27.78	.96966	37	728.65287	.43338
898	May 17	42 57	49 28	1,463	0	2.4	33.27	26.57	.97412	148	0	0
					25	.0	33.41	26.85	.97374	121	24.34825	.03360
					50	.6	33.90	27.21	.97328	86	48.68600	.05950
					125	2.0	34.28	27.41	.97277	69	121.66287	.11755
					250	2.8	34.59	27.60	.97203	51	243.21287	.19288
					450	3.0	34.71	27.68	.97108	46	437.52387	.29038
					750	2.8	34.75	27.73	.96971	42	728.64237	.42288

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	V−V₁	E	E−E₁
		° ′	° ′	*Meters*		°*C.*	‰					
899	May 17	42 55	49 05	2,012	0	7.0	33.83	26.53	0.97415	151	0	0
					25	6.8	34.26	26.89	.97370	117	24.34812	.03347
					50	5.2	34.29	27.11	.97338	96	48.68662	.06012
					125	4.8	34.53	27.35	.97283	75	121.66949	.12437
					250	4.8	34.84	27.59	.97206	54	243.22511	.20512
					450	4.8	34.86	27.61	.97116	54	437.54711	.31362
					750	[2] 5.8	34.92	27.54	.96994	65	728.71211	.49262
900	...do.....	43 23	49 21	75	0	2.0	33.17	26.53	.97415	151	0	0
					25	1.2	33.24	26.64	.97394	141	24.35112	.03647
					50	1.8	33.32	26.66	.97380	138	48.69787	.07137
					60	2.0	33.57	26.84	.97359	122	58.43482	.08437
901	May 18	43 33	49 00	2,012	0	2.0	33.12	26.48	.97420	156	0	0
					25	.4	33.73	27.08	.97353	100	24.34662	.03197
					50	.7	34.03	27.31	.97319	77	48.68062	.05412
					125	2.6	34.19	27.30	.97288	80	121.65824	.11312
					250	2.8	34.68	27.67	.97197	45	243.21136	.19137
					450	3.0	34.73	27.70	.97106	44	437.51436	.28087
					750	2.8	34.78	27.75	.96969	40	728.62686	.40737
902	...do.....	43 35	49 06	1,463	0	1.8	33.17	26.54	.97414	150	0	0
					25	2.0	33.30	26.63	.97395	142	24.35112	.03647
					50	1.6	33.55	26.86	.97361	119	48.69562	.06912
					125	1.4	34.11	27.32	.97286	78	121.68824	.14312
					250	1.8	34.33	27.47	.97216	64	243.25199	.23200
					450	1.4	34.59	27.71	.97104	42	437.57199	.33850
					750	[1] 2.8	34.73	27.71	.96973	44	728.68749	.46800
903	...do....	43 37	49 11	1,097	0	1.5	33.05	26.46	.97422	158	0	0
					25	.7	33.15	26.60	.97388	135	24.35125	.03660
					50	−.8	33.31	26.80	.97367	125	48.69562	.06912
					125	−.8	33.54	26.98	.97317	109	121.70212	.15700
					250	1.1	34.37	27.55	.97208	56	243.28024	.26025
					450	2.0	34.50	27.59	.97116	54	437.60424	.37075
					750	2.8	34.59	27.68	.96976	47	728.74224	.52275
904	...do....	43 39	49 16	412	0	1.8	33.04	26.44	.97424	160	0	0
					25	−.6	33.35	26.82	.97377	124	24.35012	.03547
					50	−.7	33.42	26.88	.97359	117	48.69212	.06562
					125	−.4	33.57	27.00	.97315	107	121.69487	.14975
					250	1.1	34.06	27.31	.97231	79	243.28612	.26613
905	May 19	43 33	49 32	55	0	2.6	33.07	26.40	.97428	164	0	0
					25	1.4	33.16	26.56	.97402	149	24.35375	.03910
					40	1.6	33.24	26.61	.97389	143	38.96307	.06097
					50	3.0	33.38	26.62	.97384	142	48.70172	.07522
906	...do....	43 23	49 14	686	0	1.2	33.06	26.49	.97419	155	0	0
					25	−.8	33.25	26.75	.97383	130	24.35025	.03560
					50	−1.0	33.51	26.97	.97351	109	48.69275	.06625
					125	−.8	33.56	27.00	.97315	107	121.69250	.14738
					250	.4	33.78	27.12	.97248	96	243.29438	.27439
					450	2.0	34.46	27.56	.97119	57	437.66138	.42789
					650	1.0	34.66	27.79	......	......	631.78638	......
907	...do....	43 15	49 04	1,143	0	1.9	33.03	26.42	.97426	162	0	0
					25	1.5	33.15	26.54	.97403	150	24.35362	.03897
					50	2.0	33.32	26.65	.97381	139	48.70162	.07512
					125	2.0	34.09	27.26	.97292	84	121.70399	.15887
					250	2.2	34.33	27.44	.97218	66	243.27274	.25275
					450	2.7	34.41	27.46	.97129	67	437.61974	.38625
					750	3.2	34.52	27.51	.96992	63	728.80124	.58175
908	...do....	43 10	48 52	2,195	0	2.4	32.89	26.28	.97439	175	0	0
					25	.6	33.38	26.79	.97380	127	24.35237	.03772
					50	.5	33.71	27.06	.97343	101	48.69274	.06624
					125	2.0	34.16	27.32	.97290	82	121.68011	.13499
					250	3.1	34.47	27.47	.97216	64	243.24636	.22637
					450	4.0	34.67	27.54	.97122	60	437.58436	.35087
					750	4.2	34.65	27.51	.96994	65	728.75836	.53887
909	...do....	43 03	48 43	3,292	0	7.8	33.52	26.16	.97451	187	0	0
					25	7.2	33.84	26.51	.97406	153	24.35712	.04247
					50	3.8	33.91	26.96	.97352	110	48.70187	.07537
					125	3.8	34.33	27.29	.97289	81	121.69224	.14712
					250	5.1	34.68	27.43	.97221	69	243.26099	.24100
					450	4.2	34.72	27.56	.97120	58	437.60199	.36850
					750	4.6	34.77	27.56	.96990	61	728.76699	.54750
910	...do.....	42 58	48 32	3,292	0	5.8	33.37	26.31	.97436	172	0	0
					25	5.6	33.75	26.30	.97426	173	24.35775	.04310
					50	8.7	33.86	26.30	.97415	173	48.71287	.08637
					125	4.8	34.31	27.18	.97299	91	121.73062	.18550
					250	4.6	34.59	27.42	.97222	70	243.30624	.28625
					450	4.5	34.75	27.55	.97132	70	437.66024	.42675
					750	4.2	34.54	27.55	.97000	71	[illegible]	[illegible]

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.
[2] Values obviously in error, but included for completeness and to show what was actually recorded.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.	Longitude, W.	Depth	Decibar levels	Temperature	Salinity	δ_t	V	V–V₁	E	E–E₁
		° ′	° ′	Meters		°C.	‰					
911	May 24	42 33	50 43	2,057	0	3.0	33.48	26.69	0.97400	136	0	0
					25	–.1	33.56	26.97	.97363	110	24.34537	.02072
					50	.1	33.70	27.07	.97343	101	48.68349	.05699
					125	2.8	33.96	27.10	.97307	99	121.67686	.13174
					250	1.5	34.09	27.30	.97232	80	243.26373	.24374
					450	2.8	34.58	27.59	.97116	54	437.61173	.37824
					750	3.1	34.69	27.66	.96978	49	728.75273	.53324
912	---do----	42 37	51 02	1,902	0	2.8	33.20	26.49	.97419	155	0	0
					25	–.1	33.41	26.85	.97374	121	24.34912	.03447
					50	–.6	33.38	26.85	.97362	120	48.69112	.06462
					125	–.6	33.64	27.05	.97310	102	121.69312	.14800
					250	2.1	34.22	27.36	.97226	74	243.27812	.25813
					450	2.6	34.56	27.59	.97116	54	437.62012	.38663
					750	3.1	34.67	27.64	.96979	50	728.76262	.54313
913	May 26	42 13	50 29	2,972	0	4.1	33.29	26.44	.97424	160	0	0
					25	1.8	34.15	27.33	.97329	76	24.34413	.02948
					50	1.8	34.18	27.35	.97315	73	48.67463	.04813
					125	1.6	34.21	27.39	.97279	71	121.64738	.10226
					250	2.6	34.52	27.56	.97207	55	243.20113	.18114
					450	3.2	34.66	27.62	.97113	51	437.52113	.28764
					750	3.2	34.70	27.65	.96978	49	728.65763	.43814
914	---do----	42 15	50 20	2,972	0	5.0	33.30	26.35	.97432	168	0	0
					25	3.9	33.24	26.42	.97415	162	24.35587	.04122
					50	1.4	33.53	26.86	.97361	119	48.70287	.07637
					125	1.7	34.38	27.51	.97268	60	121.68874	.14362
					250	2.8	34.56	27.58	.97205	53	243.23436	.21437
					450	3.0	34.67	27.65	.97110	48	437.54936	.31587
					750	3.2	34.75	27.69	.96975	46	728.67686	.45737
915	May 27	41 45	49 40	3,200	0	18.6	36.00	25.90	.97475	211	0	0
					25	18.6	35.97	25.88	.97467	214	24.36775	.05310
					50	18.5	35.98	25.91	.97452	210	48.73262	.10612
					125	15.2	[1] 35.68	[1] 26.60	.97356	148	121.78562	.24050
					250	12.4	35.37	26.81	.97283	131	243.43499	.41500
					450	8.2	34.89	27.18	.97160	98	437.87799	.64450
					750	5.0	34.84	27.57	.96990	61	729.10299	.88350
916	May 28	41 57	49 04	3,338	0	5.0	33.54	26.54	.97414	150	0	0
					25	7.2	33.98	26.62	.97396	143	24.35125	.03660
					50	6.4	34.16	26.87	.97361	119	48.69587	.06937
					125	5.8	34.54	27.24	.97294	86	121.69149	.14637
					250	6.1	34.61	27.25	.97239	87	243.27461	.25462
					450	4.4	34.74	27.56	.97120	58	437.63361	.40012
					750	4.1	34.86	27.69	.96977	48	728.77911	.55962
917	May 29	41 45	49 15	3,292	0	4.7	33.30	26.38	.97430	166	0	0
					25	4.1	33.37	26.51	.97406	153	24.35450	.03985
					50	3.8	33.50	26.64	.97382	140	48.70300	.07650
					125	2.2	34.08	27.24	.97293	85	121.70612	.16100
					250	5.6	34.74	27.42	.97222	70	243.27799	.25800
					450	4.5	34.77	27.57	.97119	57	437.61899	.38550
					750	3.2	34.72	27.68	.96976	47	728.76149	.54200
918	May 30	41 12	47 58	3,475	0	6.4	33.07	26.00	.97466	202	0	0
					25	6.4	32.97	25.92	.97462	209	24.36600	.05135
					50	–.6	33.66	27.08	.97361	119	48.71637	.08987
					125	2.6	33.91	27.08	.97309	101	121.71012	.16500
					250	.0	34.03	27.35	.97225	73	243.29449	.27450
					450	3.0	34.59	27.58	.97117	55	437.63749	.40400
					750	3.9	34.84	27.69	.96977	48	728.77849	.55900
919	May 31	41 10	46 48	4,207	0	12.2	34.18	25.93	.97472	208	0	0
					100	12.6	35.51	26.88	.97339	120	97.40550	.16375
					200	18.1	35.26	[2] 25.47	.97432	258	194.79100	.35251
920	June 1	42 05	46 27	4,755	0	11.4	33.61	25.65	.97499	235	0	0
					25	14.8	35.19	26.19	.97437	184	24.36700	.05235
					50	11.2	35.32	27.01	.97348	106	48.71512	.08862
921	June 6	41 31	48 09	3,292	0	10.7	33.71	25.85	.97480	216	0	0
					25	8.5	33.51	26.05	.97450	197	24.36625	.05160
					50	8.2	34.79	27.10	.97340	98	48.71500	.08850
					125	5.4	34.21	27.03	.97313	105	121.70987	.16475
					250	4.9	34.53	27.34	.97230	78	243.29924	.27925
					450	5.0	34.87	27.60	.97117	55	437.64624	.41275
922	June 7	41 30	47 08	3,978	0	18.8	36.27	26.06	.97460	196	0	0
					25	18.7	36.31	26.12	.97444	191	24.36300	.04835
					50	18.7	36.30	26.11	.97433	191	48.72262	.09612
					125	16.0	36.08	26.60	.97356	148	121.76849	.22337
					250	14.8	35.94	26.76	.97289	137	243.42161	.40162
					450	10.4	35.34	27.16	.97164	102	437.86461	.63112
					750	5.4	[2] 35.67	--------	--------	-----	--------	-------

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.
[2] Values obviously in error, but included for completeness and to show what was actually recorded.

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.		Longitude, W.		Depth	Decibar levels	Temperature	Salinity	δ_t	V	V–V[1]	E	E–E[1]
		°	′	°	′	*Meters*		°*C.*	‰					
923	June 8	42	55	49	28	1,555	0	5.8	33.07	26.08	0.97458	194	0	0
							25	3.9	33.37	26.52	.97405	152	24.35787	.04322
							50	3.6	33.95	27.01	.97347	105	48.70187	.07537
							125	3.6	34.29	27.28	.97290	82	121.69076	.14564
							250	3.2	34.68	27.63	.97200	48	243.24701	.22702
							450	3.0	34.70	27.67	.97109	47	437.55601	.32252
							750	3.0	34.78	27.73	.96971	42	728.67601	.45652
924	June 9	42	49	49	44	2,286	0	5.4	33.04	26.10	.97456	192	0	0
							25	4.4	33.12	26.28	.97428	175	24.36050	.04585
							50	3.8	33.41	26.56	.97391	149	48.71287	.08637
							125	2.0	34.27	27.40	.97278	70	121.71374	.16862
							250	3.0	[1]34.50	27.51	.97212	60	243.26999	.25000
							450	2.0	34.73	27.73	.97103	41	437.58499	.35156
							750	3.2	34.80	27.73	.96971	42	728.69599	.47650
925	...do....	43	16	49	10	823	0	4.8	33.07	26.20	.97447	183	0	0
							25	3.6	33.17	26.39	.97418	165	24.35812	.04347
							50	3.0	33.51	26.72	.97374	132	48.70712	.08062
							125	1.2	34.08	27.31	.97296	88	121.70837	.16325
							250	2.0	34.32	27.45	.97217	65	243.27899	.25900
							450	2.9	34.58	27.54	.97121	59	437.61699	.38350
							750	3.2	34.66	27.64	.96979	50	728.76699	.54750
926	June 10	43	10	49	34	274	0	4.8	32.97	26.10	.97456	192	0	0
							25	2.0	33.18	26.53	.97404	151	24.35750	.04285
							50	−1.6	33.32	26.83	.97363	121	48.70337	.07687
							125	.6	33.81	27.14	.97302	94	121.70274	.15762
							200	.6	34.12	27.38	.97246	72	194.65824	.21975
							240	1.6	34.11	27.31	.97233	------	233.55404	--------
927	...do....	42	59	49	27	1,463	0	5.2	32.99	26.09	.97457	193	0	0
							25	4.8	33.02	26.16	.97440	187	24.36212	.04747
							50	4.8	33.45	26.49	.97396	154	48.71662	.09012
							125	−.3	33.76	27.14	.97302	94	121.72837	.18325
							250	1.4	34.17	27.37	.97225	73	243.30774	.28775
							450	1.0	34.48	27.65	.97108	46	437.64074	.40725
							750	3.0	34.63	27.61	.96982	53	728.77574	.55625
928	June 11	43	02	49	00	1,463	0	5.1	33.12	26.20	.97447	183	0	0
							25	5.2	33.41	26.42	.97415	162	24.35775	.04310
							50	3.4	33.56	26.74	.97372	130	48.70612	.07962
							125	2.0	34.44	27.54	.97265	57	121.69499	.14987
							250	2.6	34.58	27.61	.97202	50	243.23686	.21687
							450	3.0	34.70	27.67	.97109	47	437.54786	.31437
							750	3.0	34.79	27.76	.96968	39	728.66336	.44387
929	...do....	42	57	48	55	1,646	0	6.6	33.51	26.32	.97435	171	0	0
							25	4.1	33.86	26.89	.97370	117	24.35062	.03597
							50	3.5	34.16	27.19	.97330	98	48.68812	.06162
							125	2.4	34.45	27.52	.97267	59	121.66199	.11687
							250	2.9	34.58	27.58	.97205	53	243.20699	.18700
							450	3.1	34.67	27.64	.97111	49	437.52299	.28950
							750	3.1	34.73	27.69	.96975	46	728.65199	.43250
930	June 12	44	00	48	20	3,292	0	8.2	33.71	26.25	.97442	178	0	0
							25	5.4	33.89	26.77	.97382	129	24.35300	.03835
							50	3.2	34.15	27.21	.97328	86	48.69175	.06525
							125	3.0	34.50	27.51	.97268	60	121.66525	.12013
							250	3.8	34.93	27.77	.97188	36	243.20025	.18026
							450	3.6	34.94	27.81	.97096	34	437.48425	.25076
							750	3.8	34.85	27.71	.96974	45	728.58925	.36976
931	June 13	43	06	49	45	190	0	5.0	32.94	26.08	.97458	194	0	0 85
							25	−.4	33.24	26.72	.97386	133	24.35550	.040
							50	−1.4	33.37	26.87	.97359	117	48.69862	.07212
							125	−.4	33.44	26.88	.97326	118	121.70549	.16037
							175	−1.0	33.56	27.01	----------	------	170.35949	--------
932	June 14	42	00	50	08	3,475	0	6.0	33.39	26.29	.97438	174	0	0
							25	4.8	33.49	26.52	.97405	152	24.35537	.04072
							50	3.2	33.72	26.87	.97360	118	48.70099	.07442
							125	2.2	34.33	27.44	.97274	66	121.68874	.14392
							250	3.0	34.59	27.58	.97205	53	243.23811	.21816
							450	3.4	34.70	27.63	.97112	50	437.55511	.32162
							750	3.4	34.74	27.66	.96979	50	728.69161	.47212
933	June 16	42	52	49	43	1,317	0	4.4	33.03	26.21	.97446	182	0	0
							25	3.8	33.10	26.32	.97424	171	24.35875	.04148
							50	−.6	33.34	26.81	.97366	124	48.70750	.08101
							125	1.0	34.01	27.27	.97290	82	121.70350	.15201
							250	2.4	34.42	27.49	.97214	62	243.26850	.24050
							450	3.0	34.63	27.62	.97113	51	437.59550	.36038
							750	3.2	34.68	27.64	.96979	50	728.73350	.51481

[1] Values by interpolation on account of loss of water somple, failure of thermometers to work, etc

Oceanographic station data and dynamic calculations, 1928—Continued

Station	Date	Latitude, N.		Longitude, W.		Depth	Decibar levels	Temperature	Salinity	δ_t	V	$V-V_1$	E	$E-E_1$
		°	′	°	′	*Meters*		°*C.*	‰					
934	June 18	43	33	48	58	2,012	0	6.6	33.25	26.12	0.97454	190	0	0
							25	5.4	33.22	26.24	.97432	179	24.36075	.04610
							50	−.6	33.91	27.27	.97324	82	48.70525	.07875
							125	1.0	34.16	27.39	.97278	70	121.68100	.13588
							250	2.1	34.44	27.53	.97210	58	243.23600	.21601
							450	2.9	34.54	27.55	.97120	58	437.56600	.33251
							750	3.0	34.68	27.65	.96978	49	728.71300	.49351
935	...do....	45	34	48	21	773	0	3.6	33.05	26.29	.97438	174	0	0
							25	.4	33.20	26.65	.97393	140	24.35387	.03922
							50	−1.6	33.78	27.20	.97330	88	48.69424	.06774
							125	.0	[1] 34.00	27.32	.97285	77	121.67486	.12974
							250	1.9	34.34	27.47	.97216	64	243.23798	.21799
							450	3.0	34.63	27.61	.97114	52	437.56798	.33449
							750	3.2	34.59	27.57	.96986	57	728.71798	.49849

[1] Values by interpolation on account of loss of water sample, failure of thermometers to work, etc.

U.S. TREASURY DEPARTMENT - UNITED STATES COAST GUARD

BULLETIN No. 18

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN - [SEASON of 1929]

U. S. TREASURY DEPARTMENT

UNITED STATES COAST GUARD

Bulletin No. 18

INTERNATIONAL ICE OBSERVATION AND ICE PATROL SERVICE

IN THE

NORTH ATLANTIC OCEAN

Season of 1929

UNITED STATES
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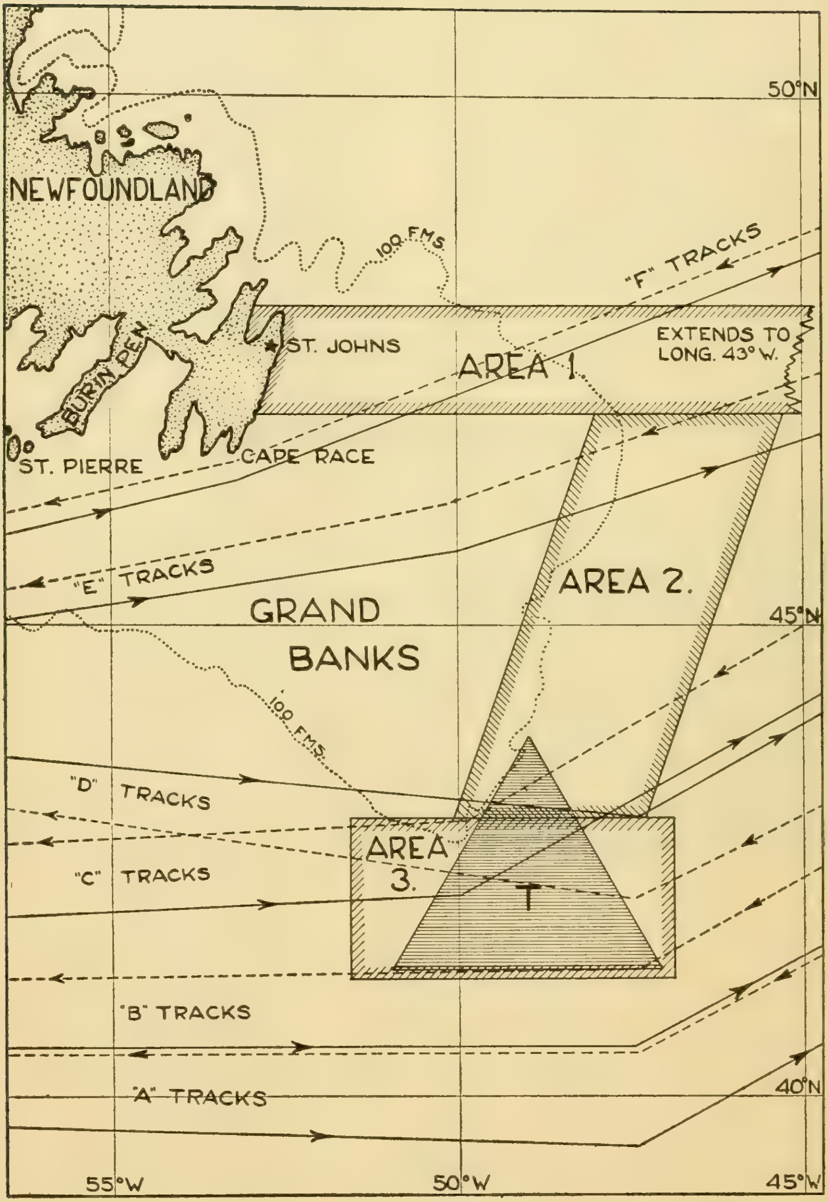


FIGURE 1.—The scene of the principal activities of the International Ice Patrol. Tracks A, B, and C are routes to and from United States ports. Tracks D, E, and F are routes to and from Canadian ports. Areas 1, 2, and 3 make up the "melting area" described in the chapter on oceanography. Fully 90 per cent of the icebergs that drift south of the 48th parallel each year disintegrate in this "melting area" covering in all some 74,000 square sea miles. The triangle "T" is a very critical area and must be frequently searched out for ice by the patrol vessels themselves

INTRODUCTION

In 1855 Matthew F. Maury, later to be known as "The Pathfinder of the Seas," was a lieutenant in the United States Navy and in charge of the Naval Observatory at Washington, D. C. In January of the above year he began strenuously advocating in the interests of safety separate travel lanes for eastbound and westbound traffic between Europe and America. The cause of the great concern was a disastrous collision between eastbound and westbound vessels, in which 300 lives were lost. There was some opposition at first, but in the course of a few years a mounting list of disasters through collision forced such a system of tracks to be put into effect. Although the danger of collision between vessels was thus greatly lessened, there remained the problem of the ice menace that threatens in the vicinity of the Grand Banks off Newfoundland each spring.

In 1890 Hugh Rodman, then an ensign in the United States Navy, was ordered to proceed to Newfoundland and Nova Scotia to make investigations relative to the ice. The information that he obtained was combined with that accumulated through reports for many years from shipping and was published by the Hydrographic Office as a pamphlet entitled "Report of Ice and Ice Movements in the North Atlantic Ocean." A partial list of disasters contained therein shows that from March 19, 1882, to April 16, 1890, there were no less than 14 vessels lost and about 40 vessels seriously damaged in the North Atlantic due to ice. Among these were many trans-Atlantic steamers that had collided with icebergs. The Hydrographic Office admitted that if reports had been received of all the fishing and whaling vessels lost or damaged the list would have been much larger.

A study of the records up to 1890 clearly showed that the ice came down from the north in larger amounts and extended farther to the southeast of Newfoundland in some years than in others. The heavy ice years were the ones when the greatest toll of trans-Atlantic vessels was taken. Continual efforts were made to gather reports of ice conditions, and the United States Hydrographic Office gave out its information to the shipping interests as quickly and in as much detail as possible. Other than accumulating ice reports on shore from shipmasters, nothing new was done to combat the danger until after the world had been horrified by the *Titanic* disaster of April 14, 1912, in which over 1,500 persons lost their lives. The *Titanic* sank on her maiden voyage shortly after collision with an iceberg in latitude 41° 46′ N., longitude 50° 14′ W.

Resolved to prevent the repetition of such a tragedy and to meet the almost universal demand for a patrol of the ice zone to warn passing vessels of the limits of danger from day to day during the ice season, the United States Navy scout cruisers *Birmingham* and *Chester* were ordered to inaugurate such a service that was to continue until the end of the ice season of 1912. Very opportunely, radio had been developed and brought into use by this time, so that much more information could be gathered and disseminated by a ship on patrol in 1912 than would have been possible even a few years earlier. During the season of 1913 the patrol was undertaken by the Treasury Department and performed by the Coast Guard cutters *Seneca* and *Miami*.

At the International Conference on the Safety of Life at Sea, signed at London on January 20, 1914, the high contracting parties provided for the inauguration of an international service of ice observation, ice patrol, and ocean derelict destruction in the North Atlantic. The Government of the United States was invited to undertake the management of this triple service, the expense to be defrayed by the high contracting parties in a fixed proportion. The proposition was favorably considered by the President, and on February 7, 1914, he directed that the (then) Revenue Cutter Service begin as early as possible in that month the international ice-observation and ice-patrol service. Each year since then, with the exception of the years 1917 and 1918, a patrol has been maintained by the Coast Guard. Two of the largest and best equipped of the United States Coast Guard cutters have been ordered from their home stations and detailed to keep close watch on the ice so as to be able to warn shipping promptly and effectively of the position and movements of the menacing bergs and floes. The cutters inaugurate the patrol very early in the spring, as soon as the ice begins to push south along the eastern edge of the Grand Banks, and one of the two always remains on duty in the ice area until summer time conditions so melt back the limits of ice that it no longer constitutes a serious menace to the trans-Atlantic lane routes.

The three southernmost pairs of tracks between North America and Europe (see fig. 1, United States Coast Guard Bulletin No. 17) carry the fastest as well as the largest amount of traffic and are the lanes that the ice patrol strives particularly to guard. They are laid down well to the south of the usual limits of field ice, so the patrol does not have to contend with that sort of ice itself or to warn the United States-Europe traffic of it to any great extent. The ice patrol's great problem is berg ice from the Greenland ice cap. The solid, massive bergs persist in the ocean much longer and extend to far lower latitudes before they melt than does the field ice. For instance, about 1,000 miles east of the American coast in 1928 one berg drifted to the

latitude of Washington, D. C., just south of the thirty-ninth parallel, before it disappeared. During the same year the most southerly report of field ice, outside of that which was reported from the approaches to the Gulf of St. Lawrence, was far to the north of the latitude of Portland, Me., or Halifax, Nova Scotia. The field ice of the Grand Banks region is broken off from the outer limits of the Arctic pack ice, or is formed locally on the surface of the sea along the North American coast to the northward of Cape Race, Newfoundland. Bad as it is for shipping north of the forty-seventh parallel at times, it is, when compared with the bergs, a relatively short-lived ephemeral affair, even along the northern tracks that run across the Grand Banks.

The patrol vessels do not attempt to destroy the bergs, as many people have been led to think through reading erroneous statements that sometimes get into newspapers and news reels after demolition experiments have been carried out on the ice. Except under very favorable conditions, bergs are dangerous to board in the open ocean because of the wash of the sea against their hard steep sides. The risks are augmented by the fact that the sea about them is usually icy and boisterous in early spring. Later on when conditions have ameliorated the bergs are much more frequently cracking up, dropping off large overhanging ice masses, and turning over.

The ice patrol's experiments have shown that mining operations with high explosives, in the few cases when they are practicable are almost useless. The large bergs are so deep lying, massive, and hard that the explosion of a hundred pounds, more or less, of T. N. T. has very little effect other than to increase the size of the hole in which the charge is placed and to shake off a few pieces of ice already about to fall. Gunfire is even more futile than mining. Well placed shots will sometimes bring down a few tons of ice into the sea, but when it is considered that 500,000-ton bergs are not uncommon and that only about one-fourth to one-sixth of the mass of a berg projects above water to serve as a target, the futility of this method of attack becomes apparent.

The series of experiments on the destruction of bergs undertaken by Prof. H. T. Barnes, of McGill University, have been followed by the ice-patrol authorities with interest. His thermite charges seem to give a little more promise of success than any other method evolved to date, but there are grave practical difficulties connected with placing the thermite in the heart of the bergs where it can act most effectively. Up to the present time, at least, it would seem that the only practicable thing that can be done is to watch, and to keep shipping advised of the changing positions of the various southernmost bergs and ice fields until in the natural course of events they melt. They disappear rather rapidly as they drift south into warmer waters during the advance of spring. As stated above, the field ice is disposed

of very rapidly in the open ocean about the Grand Banks. Even the bergs have a comparatively short life there. Each one of the latter presents a special problem of melting, depending on its size, shape, and solidity, as well as on the sort of weather and water that it encounters. Along the northern edge of the Gulf Stream the accumulated observations of the ice patrol show that the largest and most resistant bergs can last only about two weeks.

The thing that most hampers the patrol in its service of information is the prevalence of fog in the ice-infested regions. Experience shows that quick advantage must be taken of every spell of good weather if anything approaching an efficient information system is to be maintained. The critical areas just north of the southernmost steamer lanes must be searched again and again for ice during the course of the season. At night, and also when dense Grand Banks fog closes in, the patrol vessels usually stop and drift. This procedure not only insures that no bergs are passed unnoticed because of bad visibility, but also conserves fuel, which permits higher speed cruising when the weather is clear and bright.

Much scientific work has been done in conjunction with the ice patrol and much statistical data regarding the ice has been gathered and published in the annual ice-patrol bulletins. A great deal more is now known about the Labrador Current and the Gulf Stream in the vicinity of the Grand Banks than was known when the *Titanic* went down. There is still much work to be done before the great variation in the severity of the ice seasons from year to year can be fully explained, however, and before the final drift tracks of bergs that are seen off the eastern edge of the Grand Banks can be predicted with confidence.

The international ice patrol for the season of 1929 was carried on by the United States Coast Guard cutters *Tampa* and *Modoc*. The *Mojave* acted as the stand-by vessel, but she was not called upon for active duty on patrol. Commander Thomas M. Molloy, in addition to being in command of the *Tampa*, was commander, international ice patrol. Commander Philip F. Roach was in command of the *Modoc*. Lieut. Commander Noble G. Ricketts was detailed as ice observation officer and remained at sea with two enlisted men as assistants throughout the patrol season in order to aid the commanding officer of the vessel actually on duty in ice-patrol matters and to keep a continuous and uniform record of the year's work for this annual report.

Halifax, Nova Scotia, was the base for fuel and supplies during the ice season. The *Tampa* and *Modoc* made alternate cruises of about 15 days each in the ice regions, this time being exclusive of the five or six days occupied in going to and from the base.

Eight times each day radio broadcasts giving locations or limits of all known ice in the North Atlantic were transmitted for the benefit of shipping approaching the ice-patrol area. The different bergs, if not again sighted or reported, were kept from five to seven days in the broadcasts before they were dropped.

The probable drift tracks of critical bergs were indicated when possible. The surface isotherms were very successfully used to estimate probable berg drift tracks and to determine limits of ice areas to be searched. The isotherm curves were drawn partly from information obtained by the ice-patrol vessels themselves, but mainly from careful plotting and analysis of the surface water temperature reports received by radio from cooperating vessels. The value of these reports can not be overestimated, and it is hoped that their number will increase annually. When every vessel crossing the ice-patrol area, particularly those off the most usually traveled routes, reports regularly to the patrol, then the latter will be able to render the most efficient and useful service possible.

Special messages were drafted and sent to any ship that inquired for special information relative to ice, weather, routes, and similar matters. The successive positions of vessels as plotted from their water temperature reports were carefully watched. Whenever it was apparent that a ship was following a course leading toward danger the master was warned, safer courses or other suitable precautions being suggested. Once each day a compilation of all ice sighted or reported during the previous 24 hours was transmitted by radio direct to the United States Hydrographic Office at Washington, D. C. These reports were given wide dissemination among shipping circles by the hydrographer of the United States Navy.

The scientific work carried on by the patrol in 1929 was similar to that of previous years. Deep-sea soundings were obtained by the echo method at frequent intervals for the purpose of improving the bathymetrical charts of the ice-patrol area. Surface and subsurface temperatures and salinities were determined at numerous oceanographic stations. By the latter means it is possible to study the local currents generated where the Labrador Current meets the Gulf Stream, and to compare conditions prevailing in the different localities cruised over with those that prevailed there during former months and years. To facilitate reference and comparison the various sections of this bulletin are on the same subject matters and have been arranged in the same order as those in the 1928 Ice Patrol Bulletin, the 1928 publication itself being modeled on the form that has practically become standard during recent years.

CRUISE REPORTS

THE FIRST CRUISE, "TAMPA," APRIL 1–19

The *Tampa* left Boston, Mass., to inaugurate the 1929 international ice patrol at 12.30 p. m. on April 1. The 950-mile run to the Tail of the Grand Banks consumed four days. On April 6 a search to the northeastward for ice was started from a point about 50 miles south of the Tail, two bergs and several growlers being located in the vicinity of 42° 40′ N. 49° 30′ W. before night. Detailed reports of ice received from the Cape Race radio station and from steamers crossing the Banks showed that ice conditions were extremely bad north of the forty-fourth parallel.

April 11 saw completed the search of the cold current lying off the eastern edge of the Grand Banks between the forty-fourth parallel and the "B" United States-Europe tracks, then in effect. Four additional bergs and several growlers were located and numerous sail of the French fishing fleet were sighted. The fishermen, all about 30 days out from France, were heading west toward the Banks. Upon request, four of these vessels with sick or injured men on board were visited by the *Tampa's* medical officer.

Until the 14th the patrol remained near 42° 13′ N. 49° 33′ W., guarding the southernmost ice. During this time the first oceanographic stations of the year were occupied southeast of the Tail. On the 12th the scientific work was interrupted by a short search for the French fishing vessel *Sylvanna*, which, according to radio advices, had been abandoned on fire about 40 miles northeast of the *Tampa*. She must have sunk shortly after her entire crew of 32 had been rescued by the Swedish steamship *Malmen*, for the patrol never found other trace of her than a few charred timbers.

On April 14 the *Tampa* cruised northward up the cold current to see what ice was coming down. No new bergs were located, but patches of slush ice were seen near 43° 10′ N. 49° 45′ W. From the latter point courses were run to search out the area southwest of the Tail, where a berg was located in 42° 16′ N. 51° 04′ W. on the 15th. The next two days showed that its drift was about 6 miles per day toward the southeast. Word was received on the 16th that the Canadian ice patrol in the Gulf of St. Lawrence had been inaugurated by the ice breaker *Miquela*. The 18th and 19th were spent drifting southwest of the Tail in the first prolonged dense fog of the season. The *Modoc* arrived at a rendezvous in this area at 12.55 a. m. on April 20 and received the ice-observation party and the patrol records.

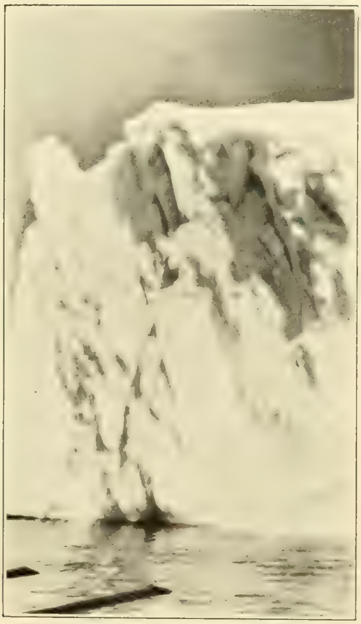


PLATE I.—Icebergs often keep their sides clifflike and perpendicular by repeated calving. When undercutting along the water line reaches a certain point the overhanging ice masses fall down into the sea, leaving a rough surface like this. Taken from a ship's boat July 15, 1929, in latitude 41° 34′ N., longitude 48° 58′ W.

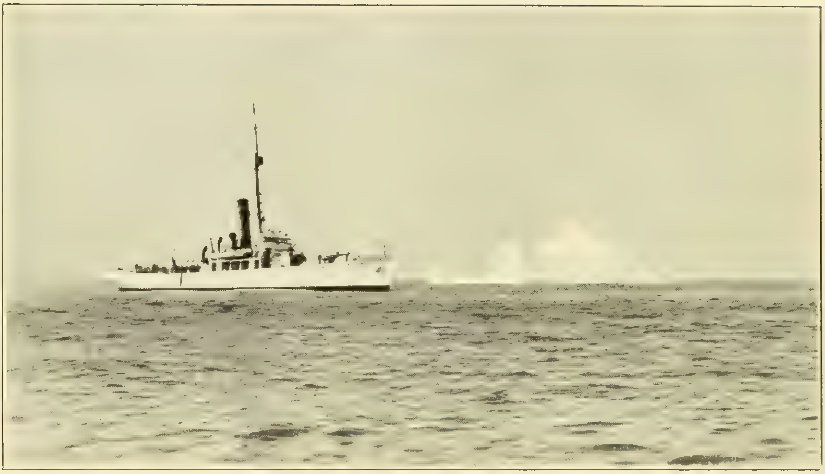


PLATE II.—The *Modoc* and a 500,000-ton iceberg. Difference in relative size of vessel and iceberg is due to the fact that in one case the ship is beyond iceberg and in other the iceberg is beyond ship. Taken from ship's boat on July 18, 1929, in latitude 42° 28′ N., longitude 50° 05′ W.

Numerous reports from passing vessels on the 17th and 18th showed that the "B" tracks were seriously threatened by a southeastward push of scattered bergs toward 42° 40′ N. 44° 50′ W. Besides mentioning this new development in the regular broadcasts, special warnings were sent out at appropriate times. Recommendation to shift the United States-Europe tracks 60 miles south from the "B" to the "A" lanes was radioed to Coast Guard headquarters on the 19th.

Earlier in the cruise the shift north of the Canadian tracks from "D" to "E" on the regular scheduled date of April 10 had been viewed with concern because heavy field ice and many bergs were known to be along the "E" tracks between the forth-seventh and forth-ninth meridians. On the 4th the *Tampa* had advised against the putting into use of these tracks until further notice. As a matter of fact they remained almost impassible until the end of the first cruise. Many liners, instead of attempting to follow them, detoured around the southern end of the heavy field ice that extended to near 45° 00′ N. 48° 30′ W. Those vessels that did use them were generally subjected to considerable delay and, it is believed, to no little danger.

About 75 different bergs drifted south of the forty-fifth parallel during the first cruise, the majority keeping within 75 miles of the eastern edge of the Grand Banks. The patrol vessel guarded particularly the southern extension of these bergs to make sure that the "B" tracks south of the Tail would not be crossed by unreported ice. All the bergs watched south of the forty-third parallel were small water-glazed ones near the end of their careers.

The weather in general was rather boisterous, with many strong breezes and a few southwesterly gales. Visibility was remarkably good throughout most of the period. Overcast nights were the rule, but the sun nearly always penetrated the cloud blanket from late morning to midafternoon.

Altogether eight oceanographic stations were occupied in scattered locations. The salinities were determined in the electric salinometer and the stations were fully computed before the relief by the *Modoc*. Dr. R. MacDonald, a marine biologist from Harvard University, accompanied the *Tampa* on the first patrol cruise for the purpose of collecting specimens from surface and intermediate levels with townets. He made 11 successful hauls at favorable times and places, the results of which will be used by him for furthering knowledge of the North Atlantic fauna.

One hundred and sixty reports of ice were received by radio from ship and shore stations. In addition the patrol vessel herself sighted and recorded the position of ice fifteen times. Ten vessels were given special ice information. This was usually sent on request, but on the 12th the *Gripsholm*, observed from her water temperature

reports, to be running toward danger in darkness, was warned on the initiative of the patrol.

The isotherm curves on the cruise chart were made up in large part from 908 sea water temperature reports received by radio from 149 different vessels. The *Tampa's* own hourly readings were used to supplement the 908 values received from shipping crossing the ice-patrol area. Unusually cold surface water, as low in temperature as 28° F., was repeatedly encountered in the area just south of the Tail of the Grand Banks. The southerly extension of cold water and ice, particularly the latter, was greater than during the corresponding period last year.

THE SECOND CRUISE, "MODOC," APRIL 19–MAY 3

The *Modoc* left Boston, Mass., at 10.30 a. m. on April 15, 1929, to relieve the *Tampa* on ice patrol. Dense fog prevailed at the rendezvous in 42° 30′ N., 51° 40′ W., on the night of April 19, but radio-compass bearings enabled contact to be made readily and searchlights penetrated the fog sufficiently to enable the ice-observation party and the patrol records to be transferred by boat as soon as the two ships met.

On the morning of April 20 word was received of the French fishing vessel *Eskualduna*, abandoned in sinking condition at 43° 40′ N., 51° 15′ W. The report being very recent and the location within eight hours' run, course was shaped for the derelict. By the evening of April 21 the area within 30 miles of the reported position had been searched. Good visibility had prevailed, but no wreckage was seen. It is believed that the vessel sank.

The French fishing vessel *Notre Dame de Bizeux* was spoken to on the Banks northwest of the Tail on the morning of April 22. She had not seen the *Eskualduna* nor heard of her abandonment, but she did have on board the master and 17 men of the *Chevalier Bayard*, a French fishing vessel that had foundered on the 16th due to taking water and to inability to run the pumps. The 18 other members of the crew of the lost vessel were distributed among three more vessels of the fishing fleet in the vicinity. The master of the *Notre Dame de Bizeux* desired the *Modoc* to take the rescued fishermen ashore from his vessel. Upon being informed that the *Modoc* could not land the men for two weeks on account of ice-patrol duties, he drafted a radiogram for transmission to the French hospital ship *Ste. Jeanne D'Arc*, requesting that vessel to relieve him of the extra men for whom he had no suitable accommodations. Continuing south, the *Modoc* on the 22d sighted seven bergs and several dozen growlers in the cold water just west of the Tail. The North Atlantic track agreement shifted from track "B" to track "A" on the 22d. Much field ice

and many bergs were reported during the first three days of the cruise from along the "E" tracks.

As April 23 was foggy all over the patrol area, no searching could be done and no ice reports were received by radio. Two oceanographic stations were taken. Advantage was taken of the fine clear weather of the 24th, 25th, and 26th to search for ice between the Tail of the Banks and the westbound "B" tracks. None was seen and none was reported in this area. On the 24th a very rough sea remained from the storm of the night before, but this gradually flattened out. On the 25th and 26th a current of 2.7 knots setting to the northeast was encountered along the forty-second parallel between the forty-ninth and fifty-first meridians. This was along the cold wall where the sea temperatures were observed to be varying between 58° F. and 38° F. within a very few miles.

No searching could be done and there was very little ice reported on the 27th, 28th, 29th, and most of the 30th because of fog. This thick weather prevented the ice-patrol vessel from supplementing with her own observations the reports made by passing vessels during the first cruise of ice in the southeastern sector.

On May 1, the visibility again being excellent, a search was started in the cold water just south of the Tail. The next day courses were run well offshore up the eastern edge of the Banks. Six bergs were sighted between the forty-eighth and fifty-first meridians north of the forty-third parallel on the two days. During the fine clear weather of the 2d no less than 56 reports of ice, all from north of the forty-third parallel, were received from other vessels. Phenomenal visibility prevailed on the second, for a medium-sized berg that later proved to be approximately 40 miles to the northeastward, was visible from the bridge at noon.

May 3 was spent searching southwestward from the forty-fourth parallel along the 100-fathom curve of the Banks. In general good visibility continued during this day, though fog banks were met at times as the ship proceeded toward a rendezvous with the *Tampa* in 42° 40′ N., 51° 40′ W. Contact was made some hours before dawn on May 4 and the relief of patrol was effected at once in the usual manner.

During the second cruise the southernmost ice was located for the most part along and just offshore of the 100-fathom curve of the eastern edge of the Grand Banks. It was in great amount north of the forty-fourth parallel. Early in the cruise field ice was reported along with the bergs as far south as latitude 44° 40′ N. By the end of the second cruise, however, the limits of the field ice had retreated to the forty-eighth parallel. Strong Gulf Stream effects prevented any bergs from drifting south of the forty-second parallel. The warm water during the cruise also removed the menace to the "B" tracks

that was threatening on April 18 in the vicinity of the forty-fifth meridian. A few bergs were reported from positions well over on the Banks. Such ice as reached the latitude of the Tail was forced close around it to the west. Although the threatening situation that existed for the "B" tracks at the beginning of the second cruise seemed to have passed for the time being, the bergs remained in such great quantities along the eastern edge of the Banks until the last of the cruise that it was thought inadvisable to recommend a shift of tracks north from "A."

Six oceanographic stations were taken and computed during the cruise. The salinities of the samples of sea water were determined on board quite satisfactorily by the method of chemical titration. As was done on all cruises, frequent soundings were made by the echo method.

Considerable fog was experienced during the second cruise, but there were also long intervening periods of fine, clear weather. During the cruise a marked transition from blustery spring conditions to more moderate summer conditions with predominating light southerly breezes took place. In the ice-patrol area the sun's rays increased in strength noticeably and commenced to warm effectively the surface layers of the sea on clear days.

Special ice information was sent to seven vessels; 957 temperature reports were received from 134 cooperating vessels. The water temperature and weather reports in addition to showing the location of the cold and warm currents, helped the patrol vessel to tell just what sections were being effectively searched by shipping and enabled her to devote her own efforts to the critical areas and to areas from which no reports were being received. During the second patrol period 203 reports of ice were received from ship and shore stations.

THE THIRD CRUISE, "TAMPA," MAY 4–19

After the *Tampa* took over the ice-patrol duty low visibility due to mist and fog patches prevailed until the 5th, on which date a search for ice was started up the eastern edge of the Banks from the latitude of the Tail. Six bergs were located in the cold stream south of the forty-fourth parallel. On the 6th the largest of these, when revisited, was found to have drifted 24 miles, 160° true, in 24 hours to 43° 04′ N., 48° 49′ W.

The 7th and 8th were foggy, but on the 9th visibility was good again. No search was started on this day, however, because a member of the crew had been operated upon for appendicitis on board the evening before and it was desired to keep the ship as steady as possible for his benefit. He rapidly recovered without complications. Twenty-five ice reports came in from north of the forty-fourth parallel during the day. One of the bergs along the

eastern edge close to the forty-sixth parallel was said to be 300 feet high.

On May 10 a second thorough search was made of the axis of the Labrador Current between the forty-fourth and forty-third parallels. One large berg was found in 43° 00′ N., 49° 20′ W. As it was drifting rapidly southward at first, it was trailed closely until the night of the 15th, when it was lost during a southerly gale with fog. Even while in waters about 34° F. in temperature this berg was seen to turn over completely at least once a day, and more frequently to list deeply. It must have been so finely balanced that slight uneven melting was sufficient to cause it to change position. Being massive and rounded, very few pieces were detached as it rolled. The southerly drift was checked at about 42° 20′ N., 49° 30′ W., from which position the movement of the berg was to the westward past the Tail, always a number of miles north of the cold wall.

From 42° 48′ N., 50° 47′ W., the drift of this berg was southward again. When lost on the 15th it was approximately in 42° 15′ N., 50° 40′ W., only 40 miles north of the westbound "B" tracks, but presumably about to be carried eastward along the cold wall. The failure of the above berg to drift south along the forty-ninth meridian into the Gulf Stream on the 11th made it seem certain that the "B" tracks were safe for the time being. Accordingly, on the evening of the 12th a message was sent to Coast Guard headquarters recommending that the United States-Europe tracks be shifted north from "A" to "B" until further notice. On the night of April 15 word was received from the Hydrographic Office that track "B" would become effective westbound on May 18 and eastbound on May 25.

During the third cruise an unusually large number of bergs were reported as between the forty-sixth and forty-eighth parallels, between longitudes 46° W. and 48° W. There were at times some remnants of field ice in the central portion of this area. Field ice and many bergs and growlers were reported by the few vessels that crossed the ice area north of the forty-eighth parallel. South of the forty-fifth parallel the bergs were comparatively few in number and widely scattered. The ones observed by the patrol decreased in size but slowly because the water around them was only 2° to 4° above the freezing point of fresh water. Eight oceanographic stations were taken and worked out during the cruise.

The fog that caused the patrol vessel to lose the berg trailed from the 10th to the 15th cleared at 2.30 p. m. on the 17th. The remainder of that day and all of the 18th were spent searching south of the Tail to relocate the southernmost known ice. The berg of the 15th could not be found again, but another berg was sighted late in the afternoon. A feature of the last two days of the patrol was a flood of

reports from between the forty-eighth and forty-ninth parallels along the "F" or Cape Race tracks, which began to be used on the regular scheduled date, May 16. Fog and rain on the "F" tracks on the 17th caused many liners to stop and drift and cut down somewhat the extraordinary number of these ice reports.

At 12.30 a. m. on May 19 the *Modoc* was met at 42° 55′ N., 52° 25′ W. There the ice-observation party and the patrol records were transferred and the relief of the patrol was effected.

Weather during the third cruise was remarkably fine and moderate on the average. There were no gales until the moderate westerly one of the 14th, which was accompanied by high barometer and clear skies. A depression that passed to the north of the patrol on the 16th caused a few hours of southerly gales with fog. Fine visibility with a clear-cut horizon was the rule, fog being experienced during but 22 per cent of the time.

One thousand and eighty-two surface water temperature reports were received from 180 vessels. These were, as always, of great value for use in planning the patrol's searching, for estimating the probable drift and life of ice, and for keeping track of shipping crossing the ice-patrol area. Two hundred and ninety-eight ice reports were received from ships and shore stations. Seventeen vessels were given special ice information.

THE FOURTH CRUISE, "MODOC," MAY 19–JUNE 2

Search courses on May 19 revealed two bergs south of the Tail. The one found in 42° 44′ N., 51° 13′ W., had drifted west-southwest at the rate of 1.3 knots since left by the *Tampa* on the 18th. On the 20th fog prevented continuance of the search for the southern limits of the cold-water area, but on the 21st fine visibility again prevailed, with the result that the ice patrol and cooperating vessels practically cleared up, for the time, the existing ice situation in the waters south of the forty-third parallel. Four bergs and one growler were believed to constitute all the ice south of the Tail, and all of these on the 21st were north of latitude 42° 30′ N. On the 21st no less than 76 reports of ice were received, a new high record for one day, proving that extremely bad ice conditions were persisting north of the forty-sixth parallel.

Unfortunately, dense fog on the 22d prevented the *Modoc* from relocating the southwesternmost ice and determining its drift toward the westbound "B" tracks. Word was received during the day from Cape Race that Cabot Straits and the Gulf of St. Lawrence were clear of ice.

When the fog cleared on the morning of May 23 another search of the southwestern portion of the cold-water area was started. Visibility gradually improved as the day went on, but no ice was located north of the "B" tracks. The 24th and 25th were spent searching

for ice in the cold water southwest of the Tail. A growler in 42° 53′ N., 51° 13′ W., was all that could be found, although visibility was good. The 26th was foggy, but on the 27th, 28th, 29th, 30th, and 31st the scouting in the cold water was continued with the idea of covering the ground thoroughly and definitely relocating the southern, western, and eastern limits of the ice.

On May 31 four large bergs were sighted close to the forty-ninth meridian between 42° 55′ N. and 43° 20′ N. One of these was a solid, massive, block of ice 115 feet high and about 400 feet square. Another large berg was seen in 43° 05′ N., 49° 29′ W. At daylight on June 1 visibility was not more than 3 miles, but it gradually increased during the day until shortly after noon it was 20 miles. The same five bergs were again sighted, although in much altered relative position due to varying currents. Dense fog prevailed on June 2 and the patrol vessel drifted.

On the morning of June 3 the fog cleared slowly. A search for ice was started to the southward, but none was seen. At 2.30 p. m. the *Tampa* relieved the *Modoc* in 42° 33′ N., 50° 20′ W.

In general, bergs continued to be unusually numerous north of the forty-fifth parallel. The only field ice heard of was that reported from north of the forty-eighth parallel by vessels on the "F" tracks. The surface water was unseasonably cold in many parts of the heavy ice area between the forty-fifth meridian and Newfoundland. The easternmost berg was reported on the 21st from 46° 50′ N., 40° 31′ W. South of the Tail of the Banks, where the *Modoc* worked most of the time, there was very little ice and the "B" tracks were not menaced.

Very few vessels reported crossing the eastern edge of the Banks between the forty-third and forty-seventh parallels. This is an important area, often called the gateway into the Atlantic for bergs. Water temperature, current, and ice conditions prevailing in it were not well known, but the patrol's duty to remain with the southernmost ice permitted but one excursion into it, and that into its extreme southern part only. Presumably very little ice was between the forty-fifth and forty-third parallels in the area concerned.

Eight oceanographic stations were taken in separated positions south of the forty-third parallel, the salinities of which were obtained at sea by the titration method without difficulty. No gales or even strong breezes were experienced on the fourth patrol cruise. Fog and visibility of less than 1 mile prevailed only 28 per cent of the time, but visibility was less than 4 miles 50 per cent of the time.

THE FIFTH CRUISE, "TAMPA," JUNE 3–18, 1929

Upon relieving the *Modoc* the *Tampa* immediately resumed the search between the Tail of the Banks and the "B" tracks to relocate the southernmost ice. On the 4th three bergs were found between

the forty-ninth and fiftieth meridians, the southernmost being a large one in 42° 33′ N., 49° 48′ W. These bergs had been sighted by the *Modoc* on the 1st, when they were located some 40 miles to the northeastward. On the 5th the southernmost berg was left to run search courses westward. Three new bergs west of the fiftieth meridian were found, but as they were no closer to the "B" tracks than the large berg in the position mentioned above, they were left and the latter closely guarded until nearly noon on June 7. From the 4th to the 7th it remained in practically the same location, disintegrating steadily but rather slowly under the influence of 38° to 42° surface water. Very many ice reports were received from all over the patrol area during this time.

The *Tampa* stood to the southeast on the 7th because of the report of a very large berg in 41° 38′ N., 48° 56′ W. All of the 8th and parts of the 7th and 9th were spent searching the vicinity of this southernmost ice when visibility permitted. It could not be found, but a current setting southeast over 48 nautical miles per day was observed near its reported position. This was along the junction of 48° mixed water and 64° Gulf Stream water. The berg was probably carried to the southeast, then east, and finally northeast clear of the "B" tracks in this swift stream, for it was never sighted and it was not reported again after the 7th.

The afternoon of June 9 was spent running northwest toward the ice known to be south of the forty-third parallel. Ten bergs of this group were reported during the day by the *Tyrifjord* from near 42° 40′ N., 49° 10′ W. On the 10th the southernmost of these bergs was reached. It was the one first sighted by the *Modoc* nine days earlier and later watched by the *Tampa* until the 7th. It had remained in practically the same location for six days. The remainder of the 10th, a day of fine visibility, was spent searching to the northwestward. Four additional bergs were located near the Tail of the Banks.

On June 11 the *Tampa* cruised to the eastward near latitude 42° 40′ N. All five bergs sighted on the 10th were cut in by bearings as the vessel steamed along, as visibility remained excellent all morning. Seven additional bergs were sighted also, making a total of 25 known bergs south of 43° 10′ N. At 4.30 p. m. the patrol stopped in haze and rain near a berg in 42° 48′ N., 48° 51′ W. Nothing was seen on the 12th because of dense fog. On the 13th six bergs were sighted along the forty-third parallel between the forty-ninth meridian and the Tail. The 14th was foggy, but late on the morning of the 15th the fog cleared so that search for the southern limits of the ice could be resumed. Observations showed that during the thick weather the *Tampa* had been carried southwest past the Tail at the rate of about 1 knot by the current. One large berg was sighted on the 15th in 42° 17′ N., 49° 23′ W.

No ice was sighted on the 16th or 17th because of dense fog. The *Tampa* drifted on those days near the southernmost known berg waiting for clearing weather and the arrival of the *Modoc*. The bad visibility was widespread over the Labrador Current, cutting down the ice reports to practically nothing on the 17th. On the 18th, which was also foggy over large areas, the two cutters steamed slowly toward each other, sighting several bergs and growlers on the way.

Relief of patrol took place in dense fog at approximately 42° 40′ N., 50° 05′ W., at 5 p. m. on June 18. The weather was so thick that the annual surfboat race between the cutters could not be held until dusk, by which time a sufficient distance had been run to the southwest to get out of the fog area and into an area of good visibility over waters warmed by the Gulf Stream.

The fifth cruise was marked by the large number of bergs between the forty-second and forty-third parallels. They did not cross the westbound "B" tracks, but seemed to spread out east and west just south of the Tail between longitudes 48° 30′ W. and 52° 30′ W., keeping, except for the berg of the 7th reported from 41° 38′ N., well to the north of the warm Gulf Stream water and north of the forty-second parallel. Throughout the cruise occasional reports of ice came in from the few vessels crossing the ocean between the Tail of the Banks and Flemish Cap. This showed that there was still ice in the Labrador Current between 43° N. and 47° N. some of which could be expected to drift below the latitude of the Tail. Bergs were unusually numerous in the much traveled waters north of the forty-seventh parallel, but they were somewhat fewer there than during the previous patrol cruise, and they were on the average distinctly farther to the westward in the ocean.

The fifth cruise saw a general rise of sea temperatures throughout the ice patrol area; 34° water was not reported from anywhere to the patrol during the last 10 days of the period, but, even so, the surface temperatures in most localities averaged from 2° to 4° colder north of the forty-second parallel than on the corresponding dates in 1928. The oceanographic equipment worked excellently throughout the fifth cruise, 10 stations being occupied and computed.

On June 7 because of the number of bergs between 42° N. and 43° N., because of the southward push of cool mixed water down to 41° 30′ N., and because of the berg reported from 41° 38′ N., 48° 56′ W., the patrol recommended that traffic be shifted from tracks "B" to tracks "A" immediately. On June 12 word was received that "A" tracks were being put into effect.

The weather was extremely moderate throughout practically all the fifth cruise, only 6 hours of gales and 10 hours of strong breezes being experienced. At night and on cloudy days the unusually cold surface water caused some comparatively low air temperatures

to be noted. The dry bulb on the bridge frequently stood at 38° F., while the ship was cruising in the cold current near the Tail.

Four hundred and thirty-six reports of ice were received and twelve vessels were sent special ice information on request. There were, as usual, a number of reports of drifting buoys and spars. The isotherms on the fifth cruise chart are based on 150 observations of the patrol supplemented by just over 1,000 values sent in by 163 different co-operating vessels.

THE SIXTH CRUISE, "MODOC," JUNE 18–JULY 2

At daylight on June 19 the *Modoc* started searching toward the southeast for a berg reported the day before from 42° 10′ N., 48° 12′ W., but this berg could not be found although search was continued throughout the 20th for it.

The 21st, 22d, and 23d were spent searching northwestward to and past 43° 00′ N., 52° 00′ W. Excellent and at times phenomenal visibility prevailed. On the 23d the *Modoc* sighted 18 bergs to the southwest, west, and northwest of the Tail. When cooperating vessels reported six additional bergs south of the forty-third parallel on the 23d and 24th it was felt that every berg comprising the southern, western, and eastern limits of the ice at the time was located and known, for reporting vessels and the *Modoc* had thoroughly covered the entire critical area.

On the 24th courses were run to the southeast for a berg reported in 42° 00′ N., 50° 00′ W. A small berg 18 miles to the northeast of this position was sighted, but no large berg could be found. During the night the *Modoc* experienced a 2-knot current setting eastward in the warm water. The rapid and varying currents so frequently found along the junction of the Gulf Stream and the Labrador Current probably account for much of the difficulty experienced in trying to find bergs in the southeastern sector, even when the searches are based upon ice reports less than 24 hours old.

The 25th and 26th were devoted to searching in the southeast branch of the cold stream for the southeastern limits of the ice. No bergs were sighted. Due to fog patches that at times interfered with visibility, the search plans had to be frequently altered and occasionally the patrol had to drift until conditions improved. As the 27th was foggy a large part of the day, little could be done other than to retain position against the strong current setting eastward along the temperature wall. Few ice reports were received on the 26th and 27th on account of the fog. The 28th commenced foggy, but northwest breezes cleared the weather over the cool water before noon, permitting a large area along the forty-second parallel between the forty-eighth and fiftieth meridians to be covered before dark. Again no bergs were found.

On the 29th fog patches were once more in evidence and interfered seriously with the search for ice. One berg was sighted at 42° 26′ N., 50° 12′ W. During the afternoon the wind increased to a moderate east-southeast gale, with rain and low visibility. The *Modoc* was stopped just west of the Tail for the night and remained stopped there throughout the 30th due to fog.

On July 1 an attempt was made to examine the area over and just south of the Tail, but fog prevailed over the cold water. The fog still persisting at 3 p. m., the attempt to search the area just south of the Banks was given up and search of the warmer southwestern area was commenced. Considerable cruising was done on the 2d, but no bergs were sighted. The *Modoc* was relieved by the *Tampa* at 42° 55′ N., 52° 19′ W., at 12.30 p. m., on July 3.

During the sixth cruise bergs were reported in considerable numbers from near the Newfoundland coast in the vicinity of St. Johns. They extended farther southwest past Cape Race than on the previous patrol cruise. Bergs were still present in large numbers just north of the Grand Banks, where at least 125 different ones, many of them large, were reported from between the forty-seventh and fifty-second meridians. From along the eastern edge of the Grand Banks there were reported no less than 50 different bergs. Between corresponding dates in 1928 there was but one berg reported and none sighted along the eastern edge and no bergs were south of the Tail.

In the latitude of the Tail, where the *Modoc* cruised and made observations, there were numerous bergs between the forty-eighth and fifty-third meridians. More than three-fourths of the bergs to reach the forty-third parallel during the sixth cruise were curved to the west and northwest around the Tail in an extension of the Labrador Current. A number of bergs drifted south along the fiftieth meridian, however, and into the Gulf Stream influence noted previously to be flowing eastward strongly near the forty-second parallel. These bergs were carried southward to a limit near 42° 00′ N., 48° 00′ W., by tongue-like pushes of cool water that extended well into the Gulf Stream drift.

In the southern sector the *Modoc* saw that disintegration of the bergs went on rather rapidly under the influence of warm sun and warming surface water. The incoming temperature reports showed higher surface temperatures in all of the ice-patrol area than during the preceding cruise period. Besides the normal seasonal warming of the surface waters there was noted considerable encroachment of Gulf Stream water over areas that during the previous cruise were occupied by cool mixed water. As the end of the cruise approached it was apparent that great changes in the distribution of surface temperatures were taking place. Warm water had pushed northeastward

to the Tail, a very favorable condition for preventing any more bergs from curving around it and drifting to the west.

Seven oceanographic stations were taken. Accidental breaking of a glass carboy containing all the silver nitrate solution of the patrol prevented the immediate determination of the salinities of the water obtained, so the cases of water samples were taken to the *Tampa* for analysis in the electric salinometer on board that vessel.

Weather was again extremely moderate and seas were generally smooth. There were only four hours of winds of gale force and seven hours of strong breezes. Fog was recorded 23 per cent of the time, and visibility of less than 4 miles 39 per cent of the time.

Three hundred and seventy-two ice reports were received from ship and shore stations. Special ice information was sent on request to 10 vessels. The cruise isotherm chart is based on the observations of the *Modoc*, as supplemented by 829 temperature reports received by radio from 151 cooperating vessels.

THE SEVENTH CRUISE, "TAMPA," JULY 3–18

The region southwest of the Tail having just been well searched by the *Modoc*, the *Tampa* on taking up the ice-patrol duty on July 3 steamed eastward slowly through dense fog to a position from which to search south and east of the Tail as soon as visibility permitted.

The opportunity came the next morning and advantage was taken of the good weather by running under forced draft during all daylight hours on the 4th and 5th. The southeastern limits of water less than 50° F. at the surface were accurately determined, and the southeast sector was carefully searched for ice. Two small bergs and one large one were all that could be found south of the forty-third parallel and east of the fiftieth meridian. The warm water seemed to be crowding north rapidly, and very little water cooler than 60° F. at the surface was left south of the forty-second parallel.

Visibility being good at times on the 6th, the patrol was enabled to search north to the Tail and thence east along the forty-third parallel to the forty-ninth meridian. One berg in 55° water at 42° 24′ N., 49° 51′ W., was the only ice sighted. In view of steadily improving conditions existing in all parts of the patrol area, word was sent the Coast Guard headquarters that the steamship tracks could be safely shifted north from "A" to "B" lanes. The latter tracks began to be used on July 13. This recommendation, as will be seen later, proved premature, but at the time made it seemed thoroughly sound.

The 7th and 8th were days of very extensive dense fog, and the *Tampa* was forced to drift, waiting for good visibility before resuming the search for the southern limits of ice and cold water. No ice was either sighted or reported on the 7th. A few reports came

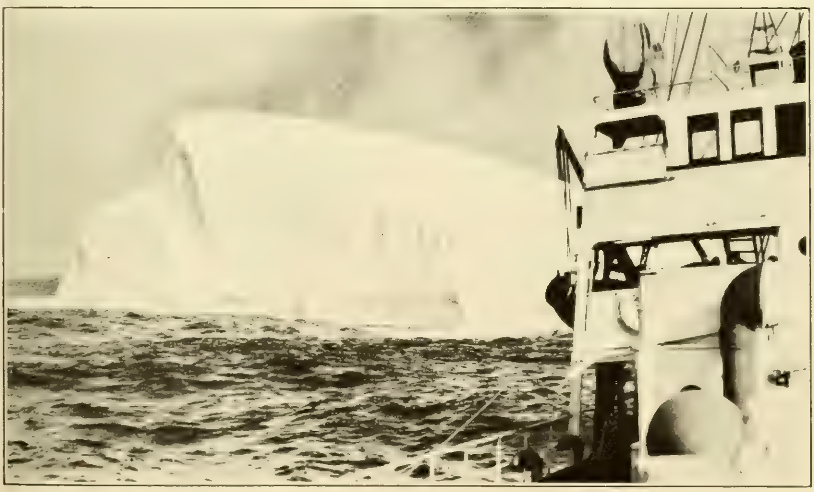


PLATE III.—The *Tampa* passing close to iceberg. In bright sunshiny weather the underwater ledges that project for short distances from some icebergs can usually be seen well enough to be avoided by a vessel moving at low speed

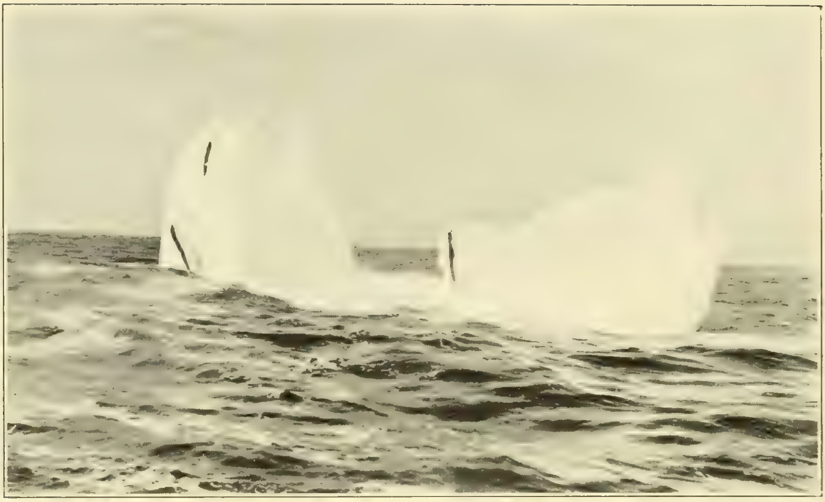


PLATE IV.—An iceberg containing a layer of black dirt-impregnated ice. Taken from height of 18 feet on patrol ship, July 16, 1929, latitude 41° 46′ N., longitude 48° 50′ W.

PLATE V.—A large iceberg taken from a height of about 90 feet on patrol ship. Note vapor coming from the melting ice, hole appearing in wall in center, and undercutting about water line of pinnacle at right. July 11, 1929, latitude 41° 34′ N., longitude 49° 00′ W.

in on the 8th from north of the Banks, however, due to breaks in the fog blanket over that region.

The 9th was foggy until 2.30 p. m., when it cleared sufficiently to permit a search north to the forty-fourth parallel. Two bergs were sighted about 40 miles east of the Tail. The next morning while running south to search again in the southeast sector, these bergs were sighted a second time and were found to have drifted southwest at a 1-knot rate. This rather rapid drift was probably due to the fresh to strong northerly breezes which cleared up the weather having temporarily accelerated the flow of the Labrador Current along the eastern edge of the Banks.

Five more bergs were sighted before dark on the 10th. One was a small one in 42° 35′ N., 49° 52′ W. The other four were large ones just south of the forty-second parallel between the forty-ninth and fiftieth meridians. The southeasternmost ones were a pair of high dry-dock type bergs located in 41° 44′ N., 49° 00′ W. These bergs were watched on the 11th and 12th, but intermittent fog and overcast weather prevented the exact determination of their drift. As the bergs were in the narrow band of water between 50° and 56° F. at the surface, they were melting rapidly. From their thin walls vapor was curling in wisps.

On the afternoon of the 11th many tons of finely cracked ice were brought down into the sea from one of these bergs by means of eleven 6-pounder shells fired for experiment into pinnacles and vertical walls. On the 13th the only one of the bergs that remained in sight broke up into a larger and a smaller part. By noon the sights showed that the larger piece was drifting rapidly north away from the "B" tracks. Accordingly, it was left for a more southerly report of ice from 42° 03′ N., 48° 41′ W. This last ice, though less than 20 miles away, was not moving northeast, but was in a south-setting eddy. On the morning of the 14th a small and a large growler, all that remained of it, was in 41° 44′ N., 48° 44′ W. This ice was left before noon for a large berg reported in 41° 34′ N., 48° 11′ W. A small smooth berg found very close to this last position was watched the remainder of the day. It rolled about frequently in melting and gave off vapor continually to the damp air.

On the 15th two bergs reported from farther to the west were approached. They were found in 41° 34′ N., 48° 58′ W. in 56° surface water, and, proving to be large ones, were closely watched throughout the 15th. Their drift was 80° true at the rate of about 1 knot. During the day several steamers passed on the westbound "B" tracks within sight of the patrol and the bergs. Conditions had materially changed for the worse since these tracks were recommended 9 days earlier, the southernmost ice being now practically on the new lanes.

The 16th was spent watching the same two bergs as they continued to move northeastward away from the tracks. By the morning of the 17th they were drifting a little south of east, however, being at 6.30 a. m. near 41° 45′ N., 48° 35′ W. The smaller of the two, marked by a layer of dirty black ice, was by this time much reduced in size and so much cut up by wave action as to be ready to break up into three pieces at any time. At 7.40 a. m. course was set for a large berg with growlers reported from 42° 07′ N., 50° 11′ W. Visibility was excellent, but no unreported ice was sighted on the way. The berg proved to be a very large, solid one over 125 feet high, floating in 58° surface water. From this berg westerly courses were steered to a rendezvous with the *Modoc* in 42° 00′ N., 52° 00′ W., near which position relief of patrol was effected at 1 a. m. on July 18, 1929.

Bergs did not curve around the Tail to the westward during the seventh cruise as they did during earlier ones. The ice, blocked from the southwest sector by a warm tongue, was carried by a push of cold water between the forty-eighth and fiftieth meridians farther south than at any other time during the year. Two or three different bergs were reported as south of 41° 30′ N. and six or eight different bergs drifted below the forty-second parallel. Throughout most of the seventh cruise the *Tampa* guarded these southeastern bergs and watched their disintegration.

There were about 20 bergs reported from along the eastern edge of the Banks and 60 from along the "F" tracks north of the Banks between 47° west and Cape Race. This was an unseasonably large number, but nevertheless it marked a considerable falling off as compared with the sixth cruise. The number of different bergs south of the forty-eighth parallel during the seventh cruise was only about half that during the sixth cruise, while the sixth cruise recorded about half as many as the fifth. It was evident that the ice was melting at higher and higher latitudes and that the arrival of the date when bergs would no longer be a menace to the "B" tracks would only be a matter of a short time.

The salinities of water samples from the seven stations taken on the *Modoc* were determined in the salinometer on the first two days of the *Tampa's* cruise. Nine oceanographic stations were taken on the seventh cruise, usually near bergs after the vessel was through cruising for the day. These salinities were determined also and all the stations were worked out before the *Modoc* was met on July 18. The oceanographic apparatus worked well. It was found that the warmth in the Labrador Current was confined to the surface layers. Even south of the forty-second parallel where the water was 56° to 64° F. at the surface, 37° and 38° water at the 125-meter level was found at all stations. Farther north the cold water was encountered

closer to the surface, sometimes at the 25-meter level and sometimes at the 50.

Winds of gale force were entirely absent during the seventh cruise and there were but two hours of strong breezes, the period being marked by fine moderate weather as a rule. On July 9 and 10 air temperatures of 44° and 43° F. were recorded while cruising in the 44° and 43° surface water to the east and northeast of the Tail. Throughout the greater part of the cruise air temperatures were in the 50's and 60's, however. Fog prevailed 29 per cent of the time and visibility of less than 4 miles 34 per cent of the time.

During the seventh cruise 131 ice reports were received from ship and shore stations. Eight vessels were sent special ice information on request. Eighty-four different vessels sent in 670 water temperature reports, which were invaluable for use in supplementing the *Tampa's* own records. The combined observations permitted an excellent idea of the distribution of Gulf Stream and Labrador Current water to be had.

THE EIGHTH CRUISE, "MODOC," JULY 18–AUGUST 1

When the *Modoc* relieved the *Tampa* on July 18 southwest of the Tail courses were laid to the eastward to examine bergs threatening the tracks between the forty-eighth and fiftieth meridians. Before dark, a medium-sized berg was sighted at 42° 28′ N., 50° 05′ W., and a larger berg of at least 500,000 tons mass at 42° 03′ N., 49° 31′ W. The latter was the one sighted by the *Tampa* on the 17th about 10 miles to the westward. The night was spent in 61° surface water near this big berg. During the hours of darkness it must have calved heavily, for it was surrounded by growlers and small pieces when it was left early on the 19th for the southeasternmost ice.

Only one of the two reported southeastern bergs was found by the *Modoc* on the 19th, and on the morning of the 20th a growler was all that remained of the one found. At 2.45 p. m. it was no longer a menace to navigation and was left for a small berg reported in 41° 09′ N., 48° 43′ W., about 60 miles to the southward. Systematic search failed to reveal this southernmost berg of the year. It probably melted quickly in the 56° to 60° surface water of the vicinity, for it was not reported again.

On the 22d, a northwesterly course was run for the British tanker *Vimeira*, of Glasgow. That vessel had struck a berg and become disabled in 42° 40′ N., 49° 44′ W., about 135 miles north of the eastbound "B" tracks, then in effect. She was reached at 5.30 p. m. and boarded. The master stated that while making 11.5 knots on an easterly course at 11.50 p. m. on July 20 his ship ran suddenly out of clear weather with bright moonlight and into a fog bank. Before speed could be reduced or he could be called she struck with

her port bow a berg that was in the fog. The berg scraped aft along the port side and bent one of the propeller blades to such an extent that the screw could not be turned over. The stem was bent and the port bow stove in from the forecastle deck to well below the water line. Only the forepeak tank was flooded, however, and the vessel was in no danger, either immediate or prospective. Many tons of ice from the berg had been forced into the forecastle through the openings made between the plates. Fortunately, the watches were being changed when the collision occurred and the bunks inside the portion of the bow that was damaged were unoccupied at the time; therefore, no person was injured.

Before the *Modoc* departed to return to the southernmost ice the master of the *Vimeira* had made arrangements by radio with the steamship *Olna* for a tow to Halifax, Nova Scotia. When the patrol vessel left the scene the berg that had caused the damage was still in sight on the horizon to the southwest.

The *Vimeira* on previous trips this year had crossed the ice-patrol area well to the southward of the Grand Banks to avoid bergs. During this last trip also she received the ice-patrol broadcasts regularly. The broadcast on the evening on which the vessel struck the berg reported a berg as on the 16th in 43° 51′ N., 49° 15′ W., and also reported a large berg as on the 17th in 43° 35′ N., 49° 14′ W., which the message stated, had probably drifted south-southwest. In all probability these two reports were on the same berg. As bergs often drift to the southward along the eastern edge of the Grand Banks at the rate of about 20 miles per day, the probable latitude of the berg on the 20th was 42° 40′ N., and it is likely that the berg struck by the *Vimeira* was the one that was on the 17th in 43° 35′ N., 49° 14′ W. The master doubtless plotted the positions of all the southernmost bergs reported in the broadcast and, noting an apparent clear space on his chart, shaped course through it. Masters should note the date of all ice reports in the broadcasts and give careful consideration to the date as well as the position of reported bergs in shaping course across the ice regions. To be certain of clearing all reported bergs due allowance must be made for their possible drifts.

On the 23d, at 7 a. m., the berg of the 17th and 18th was passed in 42° 10′ N., 49° 30′ W., still in approximately the same location as on the 17th. It had decreased considerably in size since last seen. By 9 a. m. a small berg about 30 feet high in 41° 49′ N., 49° 20′ W., the southernmost known ice, was reached. As search to the southward and westward for more ice proved unsuccessful, the patrol vessel returned to this berg late in the afternoon, finding it diminished to about 15 feet in height. When left on the morning of the 24th it was a small growler not over 3 feet high, the last trace of which must have disappeared early in the afternoon.

The berg of the 17th and 18th, being the southernmost ice remaining, was closely watched from the 24th to the 26th. On the afternoon of the 24th it calved heavily. On the 26th a few growlers were all that remained of the berg and these melted entirely shortly after dark.

The 27th and 28th were spent searching to the north for the new southern limit of the ice. The area between the forty-ninth and fifty-first meridians was covered as far as the forty-third parallel by nightfall on the 28th, but no ice was seen. The 29th, 30th, and 31st, days of dense fog, were spent just off the eastern edge of the Banks in a position to continue search northward up the cold current should good seeing weather return.

August 1 was spent running to the westward toward the *Tampa*. As soon as the warm water west of the 50-fathom curve of the Banks was reached the fog was left behind. The *Tampa* was met at 2 a. m. on August 2 in 43° 00′ N., 51° 30′ W., where the relief of patrol was effected.

Ten stations were taken during the eighth cruise. As there remained no means for determining sea-water salinity on board, the water samples were saved for analysis on the *Tampa*. Sustained winds of gale force and strong breezes were absent during the eighth cruise, which was marked by fine moderate weather. There were some sharp rain squalls, with lightning and wind, over the warm water and much fog over the cool water farther north. Fog was experienced 34 per cent of the time and visibility was less than 4 miles 46 per cent of the time.

During the eighth cruise 67 ice reports were received from ship and shore stations. Seven vessels were sent special ice information on request. Eighty-nine different coöperating vessels sent in 651 sea-water temperature reports. The isotherm chart based on these values and those obtained by the *Modoc* shows continued slow general solar warming of the surface layers. In the vicinity of 41° 00′ N., 49° 00′ W., there was a push of cold water farther south than during the last cruise, but upon the melting of the southernmost bergs the possible supply of ice for this area was cut off.

During the eighth cruise the 1929 ice menace to the Europe-United States "B" tracks definitely appeared to end. After the melting of the four bergs that were south of the forty-second parallel during the first half of the cruise the ice limits retreated steadily northward. As berg after berg of the southernmost ones melted in the summer air and sea temperatures prevailing, they failed to be replaced from the north due to lack of supply in that quarter and to probable weakening and narrowing of the Labrador Current. Persistent fog over the cold water blocked effective searching during much of the latter part of the eighth patrol period, however, and prevented a thorough clearing up of the ice situation or a definite recommendation regarding the discontinuance of the patrol.

THE NINTH CRUISE, "TAMPA," AUGUST 2-4

Upon relieving the patrol on August 2 the *Tampa* instituted a final search for the southernmost ice. By 10 a. m. the southern end of the cold current with surface temperatures between 55° and 58° F. just southeast of the Tail was entered. It was found to be but 20 miles wide, being bounded on the west, south, and east by water 60° and higher in temperature. Good visibility prevailed until the search had been carried north along the eastern edge of the Banks to 43° 30′ N. Here 52° water covered with a low fog was met. At 7 p. m. on the 2d the *Tampa* was stopped for the night in 43° 42′ N., 49° 05′ W.

The *Modoc* had watched all the bergs south of the forty-third parallel break up during the previous cruise, and only two other bergs south of the forty-eighth parallel had been reported since July 22. The more southern of these was in 44° 52′ N., 48° 34′ W., on July 27. When no ice was found in the cold water south of 43° 30′ N. by the patrol it became evident that this berg had either melted or drifted off to the northeast. It seemed a practical certainty that the ice menace for the 1929 season was absolutely over so far as the "B" tracks were concerned, and fairly certain that no more bergs could get south of the forty-third parallel before the spring of 1930. Accordingly, a message summarizing the situation and recommending the discontinuance of patrol was transmitted to headquarters on the evening of August 2.

On the 3d a southwesterly course was run across the Tail. Fine visibility prevailed over the shoal water, which was warmed to from 60° to 64° at the surface, but fog continued over the cold stream off the eastern edge. On the afternoon of the 3d, when information was received that the 1929 international ice patrol was discontinued, a course was laid for Boston, Mass. The last broadcasts of the season were transmitted on the evening of the 3d and on the morning of the 4th. They contained a notice of appreciation for the valuable assistance in the way of reports received from shipping. Port was reached without incident, and the *Tampa* moored at the Boston Navy Yard at noon on August 6, 1929, thus ending the longest ice-patrol season on record.

One oceanographic station was occupied during the ninth cruise. The water from it and from the 10 stations last taken on the *Modoc* was run through the salinometer before noon on the 4th and all stations were computed before Boston was reached. The isotherms on the cruise chart for the short ninth cruise are based on 148 values sent in by 16 different vessels and on 102 readings taken from the log of the *Tampa*. The curves show some continuation of warming in the surface layers. There was only one ice report received; one vessel given special ice information.

During the ninth cruise southwesterly breezes prevailed in the ice-patrol area, making the weather damp and muggy over the 55° to 65° water and persistently foggy over the 50° to 55° water. There were no gales, but the patrol before reaching Boston experienced some strong breezes due to the influence of two disturbances whose centers traveled across the Gulf of St. Lawrence.

RADIO COMMUNICATIONS

The radio apparatus used on the *Tampa* and the *Modoc* during the 1929 ice-patrol season was practically the same as that used by the patrol vessels during the 1927 and 1928 seasons. The main changes on each ship were the substitution of improved receivers for older types. Each ship in 1929 had for transmitting purposes one T–2 2-kilowatt tube transmitter, using either CW or ICW or phone transmission; one T–4 200-watt tube transmitter using either CW or ICW transmission; and one 500-watt XA crystal-control high-frequency transmitter. The latter type of set was very useful for clearing at scheduled times a large volume of direct traffic with NAA, the United States naval radio station near Washington, D. C. The distance between the patrol vessel on duty and that station averaged about 1,350 sea-miles.

The receiving apparatus on each ship consisted of one special high-frequency screen-grid receiver, type CGR–24, and one low-frequency receiver, type CGR–25, also screen grid. These receivers were recently manufactured for the United States Coast Guard and were the most up-to-date instruments in the service, being a big improvement over old types. They gave very satisfactory results on ice-patrol work. The 1929 receiving equipment included, in addition, the latest type direction finder or radio compass, which was invaluable for making quick and sure contact with the vessel coming out to relieve the patrol. Each vessel had also one CGR–1 receiver for use on the Coast Guard frequency band.

During the season there were no serious breakdowns of either sending or receiving sets. Free use of the good supply of spare parts and immediate rectification of all small troubles that developed combined to keep all apparatus in the radio department close to perfect operating condition at practically all times.

Normally United States Coast Guard cutters of the *Tampa* class carry four radiomen. While on ice-patrol duty this year, however, each patrol vessel carried in addition one radio electrician. This policy provided the services of an experienced supervisor on each vessel, which proved to be of great benefit, for the year 1929 had not only the longest ice-patrol season to date, but also, from a communications standpoint, by far the most arduous one on record. Due to extreme heaviness of schedule traffic, to the great number of ice

reports coming in between schedules, and to the increase in number and activity of vessels cooperating by sending in water temperatures and weather reports, the radio department was far busier in 1929 than ever before.

The figures given below indicate how the communication work of 1929 compared with that of 1928 which was a good average ice year, and, due to increasing cooperation from passing steamers, the former record year for total volume of radio traffic.

	1928	1929
Routine broadcasts transmitted	760	984
(Broadcasts averaged about 300 words each in 1928 and about 400 each in 1929.)		
Water temperature and weather reports sent in by cooperating vessels	6, 534	7, 225
Total number of cooperating vessels	489	539
Number of ice and obstruction reports received by radio	644	2, 255
Total number of words transmitted and received by radio	450, 460	807, 737

The following tabulation shows the times when the most important special ice-patrol traffic schedules were kept. The times given, which are all in Greenwich mean civil times, will doubtless be used during the 1930 season also, though there may be some slight changes necessary to make them fit in with prevailing traffic conditions at the various shore stations.

Time Remarks

0000. Radiobroadcast to shipping on 175 kilocycles.

0030. To Hydrographic Office, Washington, giving latest ice news, followed by report to Weather Bureau, Washington, giving meteorological information.

0100. Schedule with naval radio station at Bar Harbor, Me.

0230. Receive from NAA, near Washington, D. C., traffic on hand for ice patrol.

1100. Radiobroadcast to shipping on 425 kilocycles.

1148. Report to Weather Bureau, Washington, giving meteorological information.

1200. Radiobroadcast to shipping on 175 kilocycles.

1300. Schedule with naval radio station at Bar Harbor, Me.

2300. Radiobroadcast to shipping on 425 kilocycles.

SUMMARY REPORT OF THE COMMANDER, INTERNATIONAL ICE PATROL

Commander THOMAS M. MOLLOY

The *Tampa* left Boston, Mass., on April 1, to inaugurate the 1929 ice patrol. The *Tampa* and the *Modoc* each spent four full 15-day periods in the ice regions during the season. The patrol was discontinued at word received from Coast Guard Headquarters on August 3, when the *Tampa* was on the second day of the ninth patrol period. Halifax, Nova Scotia, was used as a base for fuel and supplies, as in previous years. During the season the two patrol vessels cruised a total of 23,249 nautical miles, which figure includes the distance run while going to and from the base.

The weather, as is usually the case, was raw and boisterous the first patrol cruise, but it steadily improved as the season progressed, so that during the last half of May and all of June there were but nine hours of gales. During the last month of the patrol season unusually moderate conditions prevailed, there being no gales whatever. The normal large amount of Grand Banks fog was experienced. The full season was about equally divided in point of time by foggy, clear, and overcast weather conditions.

Sixty-nine oceanographic stations were occupied during the season from time to time as opportunity offered. The salinities of the water samples were all determined on board ship and the dynamic computations were all worked out before the end of the active season. If the work of ice scouting and trailing had permitted the station work would have been more extensive and systematic. As it was, unprecedentedly heavy ice conditions required the patrol to concentrate on the practical work of watching the southernmost ice and on the service of information rather than on a comprehensive oceanographical program. Frequent soundings were taken with the fathometers, the results being tabulated for future correction and hydrographic use whenever the ship's position was well fixed by observations.

Ice was rather late in appearing in the Atlantic off the Grand Banks in 1929, and April 1, when the first vessel departed on patrol, marked a later starting of the active season than in any year since 1920, when the first vessel left New York on April 3. Because of the heaviness and persistence of the ice once it began to come down, however, the season proved an extremely long one, lasting 128 days. Word to discontinue the 1929 patrol was not received until August 3, a full

20 days later than the same word was received in 1925. Until this season 1925 had been the record year for late continuance of patrol.

Very early in the season it became evident to the patrol that the ice year was an unusual one. On the first cruise, April 1 to 19, numerous bergs were sighted and reported off the eastern edge of the Grand Banks between the forty-fifth and forty-second parallels as was to be expected, but north of 45° reports showed that ice conditions were extremely bad. One vessel that tried to use the Cape Race tracks westbound early in April was forced to skirt the edge of field ice and bergs southward for 250 miles near the forty-eighth meridian. She reported from the northern sectors "solid packed bergs and growlers extending as far as can be seen to the north, west, south, and southeast."

In view of the extremely heavy field ice and berg conditions prevailing between the forty-seventh and fiftieth meridians, the shifting north of the Canadian routes from "D" to "E" on the regular date, April 10, seemed very inadvisable to the patrol. Conditions were so bad along the "E" tracks when they were put into effect that many vessels for weeks did not try to force passage on them, but detoured to the south 80 to 100 miles so as to pass around the southern end of the field ice of the Labrador Current.

From April 20 to June 1 the field ice retreated until it was all north of the forty-ninth parallel and no longer being reported to the patrol. The bergs, however, remained in enormous numbers. They did not gain any extreme southerly positions, as nearly all of them that reached the forty-third parallel were curved to the westward around the Tail of the Banks. During June the bergs south of latitude 48° N., though still above normal in numbers, began to thin out. It is impossible to give exact figures of the numbers of bergs in any year because of great duplication of reports from near the Canadian tracks and of scarcity of reports of ice from other areas. Taking all known factors into consideration, however, it is always possible to make very fair estimates. In 1929 it is estimated that there were 460 different bergs south of the forty-eighth parallel during May and 376 different bergs during June. When it is realized that 386 bergs constitute the average number to drift south of the forth-eighth parallel during the whole of a normal ice year the severity of the 1929 season from an ice standpoint is at once apparent.

Throughout the season it was noted that the surface water was 2° or more colder than average for the date in most of the ice-patrol area north of the forty-second parallel. The amount of water just in the wave-mixed surface layers of the area concerned is so great that it is hardly conceivable that even the large number of icebergs which drifted south of the forty-eighth parallel chilled the water measurably in melting. The probabilities are that the reason for

much ice and colder water than usual in the northern half of the ice-patrol area must be searched for in some combination of causes operating to produce an unusual outpouring from the far north. The discharged waters were probably only incidentally studded with icebergs in the Grand Banks region, where, conserved by the cold water and protected against attrition by strength of numbers, they persisted to a very late date and, as mentioned above, kept the patrol in effect longer than ever before.

During June the southern part of the Labrador Current, instead of flowing westward around the Tail, as it did earlier, was split into two main branches. One of these continued to flow westward around the Tail and carried large icebergs to 43° 00′ N., 53° 00′ W., but the other branch flowed strongly southeast to 40° 00′ N., 47° 00′ W. During July the western branch noted above was wiped out and practically all the ice that got below the Tail was taken charge of by the southeast flowing stream. At least eight different bergs were carried in the latter circulation south of the forty-second parallel and close to the westbound "B" tracks during the month. The last of these bergs melted to nothing under the eyes of the patrol on July 22, and on the 26th of July the last ice south of the forty-third parallel was also observed to melt. By the latter date bergs were very sparse south of the forty-eighth parallel on account of their melting in higher and higher latitudes due to the advancing summer conditions and also to the probable shrinking and weakening of the Labrador Current.

All the bergs that were watched during the latter part of the season broke up rapidly. To illustrate the rate at which bergs can melt in warm water the case of a large berg of at least 500,000 tons mass can be given. It was first seen near 42° 00′ N., 49° 00′ W., in 61° water on July 17. In just nine days the last traces of it were closely watched as they disappeared. Such rapid disintegration is not caused by melting alone, but is greatly speeded up by frequent calving, sluffing, and division.

By the evening of August 2 it was decided that the ice menace for the "B" tracks was definitely over, and recommendation for the discontinuance of the patrol was sent to Coast Guard headquarters. This recommendation could probably have been made four or five days earlier if the ice patrol's worst enemy—fog—had not effectively and continuously blanketed nearly all the critical cold-water regions during the last week of the patrol. Permission to discontinue the patrol was received on the afternoon of August 3 and the *Tampa* reached Boston, Mass., just before noon on August 6.

It should be kept in mind that radio communication is the one thing that is of utmost value to the patrol. Without radio practically no late information could be given out and comparatively little could be gathered. In spite of the great volume of traffic caused by the un-

usually long and heavy ice season, the radio apparatus and personnel stood up excellently. Every effort is made before the season starts to see that all radio equipment is ready for the strain that will come upon it and to have the latest improvements for the sets installed. The magnitude and importance of the communication work of the patrol can be grasped in part by a study of the figures relating to volume of traffic shown on page 26 of this pamphlet.

On the night of July 20 the British tanker *Vimiera* struck a berg at 42° 40′ N., 49° 44′ W., some 70 miles north of the westbound "B" tracks, which were then in effect for passenger vessels. She was badly stove in forward and her propeller was totally disabled by the bending aft of one of its blades as the ship scraped by the berg. Fortunately, there was no loss of life or even injury to anyone. Her case should serve as a warning to the masters of other vessels to proceed cautiously when in the ice regions during all times of low visibility. Recent comparative freedom from disaster seems to be causing a growing carelessness, for the patrol noted in 1929 no less than 100 cases of failure on the part of passenger vessels to adhere to the tracks prescribed by the trans-Atlantic track agreement. Every ship that crosses the iceberg area at a speed greater that that at which she can either turn or stop before striking a berg seen ahead under the conditions of visibility prevailing is playing a game of chance.

Thanks particularly to improved radio and to more effective cooperation from shipmasters, much progress has been made during the past 14 years, and it is believed that a more efficient patrol can be maintained now than then, but it must not be thought for an instant that the ice patrol is infallible or that it is all-seeing. Broadcasts listing the positions of all the southernmost ice of which the patrol has knowledge are regularly sent out, but shipmasters must always realize that ice can move rapidly and seemingly erratically when it is off the eastern edge of the Grand Banks and still faster and more incomprehensibly when it is south of latitude 43° N. The dates given with all berg positions in the broadcasts show the freshness of the several reports. Possible drifts since time of report must be considered by shipmasters most carefully.

In view of the increasing speed and importance of trans-Atlantic travel, this summary of the 1929 ice-patrol season can not end better than by sounding a final warning by means of the words with which Capt. F. A. Levis, of the *Seneca*, closed his summary of the 1915 ice-patrol season. These words are as true now as they ever were and they will in all probability always remain true. Captain Levis said: "*Of course there is always a chance that a berg will reach the steamer tracks without being seen or reported, on account of prolonged periods of fog*, but the presence of the ice-patrol vessels near the danger zone assures passing vessels that assistance is near by in case of disaster."

Plate VI.—A tabular iceberg such as is frequently seen north of the forty-third parallel. This sort of berg is usually very stable

Plate VII.—A tabular iceberg nearing its end as such. The flat surface which was formerly the top is being slowly submerged, and the wave-cut terrace at the left is being slowly elevated due to the particular manner in which the underwater body is melting

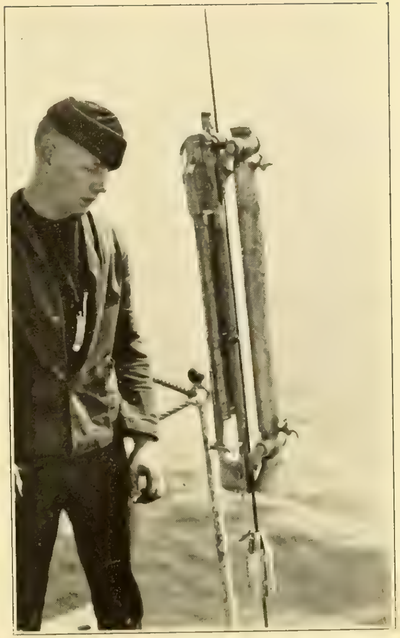


PLATE VIII. A Greene-Bigelow water bottle clamped to the sounding wire. Seven such metal bottles are clamped on at different points and lowered into the sea at each oceanographic station. The upper bottle is tripped when a messenger is slid down the wire. In tripping, a messenger is released from the bottom of the bottle to slide down to the next one in the series, and so on

PLATE IX.– Reading the reversing thermometers in a Greene-Bigelow water bottle that has been tripped on the wire at a known depth and then hoisted up and taken aboard. The cylinder fitted with two pet cocks contains over a quart of sea water from the level at which the bottle was tripped

TABLE OF ICE AND OTHER OBSTRUCTIONS, 1929

Date	No.	Reported by —	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Jan. 11	1	Cape Race Station	50 38	45 36	Berg.
24	2	do	45 28 to 45 23	59 18 to 58 08	Field ice.
25	3	do	45 00 to 45 10	59 15 to 58 20	Scattered field ice.
26	4	do	45 06 to 44 58	58 27 to 59 22	Loose field ice.
26	5	do	44 24	61 20	Slob ice.
28	6	do	45 09	59 26	Field ice in band 4 miles wide stretching north and south.
Feb. 1	7	do	45 30 to 44 45	59 10 to 60 20	Field ice covering large area.
2	8	do	44 56	60 20	Field ice.
6	9	do	44 40 to 44 45	60 37 to 59 35	Pancake ice.
14	10	do	48 11	49 50	Sludge ice.
14	11	do	44 45	59 50	Field ice.
17	12	do	47 45	51 05	Growlers extending northward.
17	13	do	44 41 to 44 39	59 49 to 60 06	Heavy field ice.
18	14	do	47 45 to 47 45	52 30 to 51 30	Light open field ice.
20	15	do	47 16 to 47 35	51 57 to 51 20	Open field ice.
20	16	do	47 35 to 47 58	51 20 to 50 43	Sludge ice.
25	17	do	47 00	52 30	Slush ice.
26	18	do	47 25 to 47 52	51 30 to 50 45	Heavy field ice.
26	19	do	48 30	49 30	Field ice.
27	20	do	46 45	51 10	Heavy field ice.
27	21	Drottningholm	47 01 to 47 07	50 01 to 49 01	Heavy patches field ice and numerous growlers.
27	22	Arnold Maersk	48 08 to 46 50	48 50 to 51 20	Heavy to light field ice.
28	23	Cape Race Station	47 02 to 46 25	47 50 to 47 40	Drift ice and growler.
Mar. 1	24	Gripsholm	45 53	47 54	Scattered growlers.
5	25	Vela	48 00	51 35	Close field ice.
10	26	Wytheville	47 14	47 34	Small growlers.
10	27	do	47 09	47 54	Large growler.
11	28	Cape Race Station	48 48 to 48 25	48 18 to 48 20	Large growlers and small pieces of ice.
11	29	do	48 25	48 20	Small berg and growlers.
11	30	do	48 04	48 12	Small berg, large growlers.
11	31	do	46 59	47 56	Small growler.
11	32	do	47 04	48 33	Small berg.
11	33	do	47 20	47 30	2 large growlers.
11	34	do	47 25	47 20	Small growler.
14	35	do	47 54 to 47 25	47 02 to 47 21	Heavy field ice, numerous growlers.
1	36	do	49 03	50 04	Heavy field ice and growlers.
2	37	do	44 35	48 34	Several growlers.
3	38	do	45 45	47 46	Several small growlers.
5	39	do	45 30	48 10	Scattered growlers.
5	40	do	47 10	49 30	Very heavy field ice.
6	41	do	45 41 to 46 10	48 46 to 47 50	Several growlers, small ice.
7	42	do	48 43	50 00	Large growlers and small ice.
8	43	do	48 43 to 47 20	50 00 to 51 40	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Mar. 10	44	Cape Race Station	47 13	48 36	Small growlers.
10	45	do	47 09	47 54	Large growler.
11	46	do	48 04	48 33	Small berg.
14	47	do	47 54 to 47 25	47 02 to 47 21	Heavy field ice, numerous growlers.
15	48	do	46 46 to 46 44	50 27 to 51 15	Heavy field ice.
16	49	Ernst Hugo Stinnes II	47 43	44 53	4 bergs with drift ice.
17	50	Lituania	48 25 to 46 39	49 51 to 52 52	Several small bergs, numerous growlers, field ice.
17	51	do	45 18	58 09	Loose field ice.
17	52	Cape Race Station	48 44 to 48 05	48 55 to 50 40	Heavy field ice, numerous growlers, and bergs.
17	53	do	46 16 to 46 10	47 38 to 48 10	Field of ice consisting of numerous growlers surrounded by heavy packed ice.
17	54	do	46 10	48 12	Low berg.
22	55	do	48 04	48 11	Small berg.
22	56	do	48 57	48 16	Small bergs.
22	57	do	48 01	48 18	Do.
22	58	do	48 02	48 21	Large growlers.
22	59	do	48 03	48 27	Small berg.
22	60	do	48 04	48 25	Small berg, open drift ice, growlers.
23	61	do	48 04 to 47 45	48 11 to 48 38	Belts of drift ice with bergs and growlers.
23	62	do	48 06	47 20	Small berg.
23	63	do	46 30	47 04	Growlers and small pieces of ice to the northwest.
23	63a	do	46 08	48 20	Small berg.
23	64	do	46 30	47 04	Growlers and small ice to northwest.
28	65	do	46 15	46 18	Large berg, small ice.
28	66	do	45 45 to 45 16	47 07 to 48 20	Several bergs, belts of field ice.
28	67	do	45 15	48 30	2 bergs.
28	68	do	46 10 to 45 30	46 30 to 47 20	Large ice field, high bergs.
28	69	do	46 15	46 18	Berg, same as 65.
28	70	do	44 54 to 44 48	58 15 to 57 20	Heavy field ice to northward.
23	71	Estonia	48 04 to 47 45	48 11 to 48 38	Belts of drift ice, small bergs, and growlers.
29	72	Cape Race Station	46 10	46 08	Berg, same as 65.
30	73	do	46 55	46 14	Heavy field ice, growlers, and bergs.
30	74	do	46 39	46 39	Berg.
30	75	do	46 30	47 27	Do.
30	76	do	46 00	47 20	Do.
30	77	do	44 40 to 44 30	48 53 to 49 15	Heavy drift ice, growlers, and 2 bergs.
31	78	do	44 30	49 00	Soft field ice with some large pieces.
31	79	do	44 46	58 18	Large patches field ice to north and northeast.
Apr. 1	80	do	46 05 to 45 08	48 18 to 48 30	Heavy field ice, numerous bergs.
1	81	do	46 04 to 47 00	50 36 to 48 45	Do.
1	82	do	43 22	49 07	Several growlers.
2	83	do	43 19	49 05	Large growlers, small bergs, small pieces.
2	84	do	43 38	48 50	Several small growlers.
2	85	do	43 10	49 00	2 small bergs, broken ice, growlers.
2	86	do	47 00 to 47 23	48 45 to 47 43	Large fields drift ice, scattered growlers, several bergs.
3	87	Hellig Olaf	45 57	47 58	Small berg and several pieces of ice.
3	88	Eastern Dawn	42 59	49 21	Large berg, several growlers.
3	89	do	43 06	49 00	Berg.
3	90	Cape Race Station	40 09	48 15	Large piece wreckage.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Apr. 3	91	Cape Race Station	43 58 to 43 54	48 51 to 49 31	Numerous growlers and small ice.
3	92	do	44 59	49 21	Large berg, several growlers.
3	93	do	48 30	49 40	Heavy packed field ice, several bergs, numerous growlers.
3	94	do	47 38	48 40	4 large bergs.
3	95	Hellig Olaf	43 34	48 56	Large berg.
3	96	do	43 26	49 09	2 large bergs, many growlers, much drift ice.
4	97	American Merchant	42 49	49 22	Large growler with 4 small ones.
4	98	do	42 43	50 31	Growler, several more 3 miles north-northwest.
4	99	do	42 49 to 42 46	49 22 to 49 44	5 small growlers.
4	100	Ilsenstein	49–30	49 40	Solid packed bergs and growlers extending north, west, south, and southeast.
4	101	do	49 30 to 47 38 to 45 20	49 40 to 47 30 to 47 50	Field ice, numerous growlers, and about 40 large bergs.
4	102	do	45 20 to 44 54	47 50 to 48 29	Field ice and growlers.
5	103	MacFarlane	44 40	48 11	3 large, 1 small berg.
5	104	do	44 18	48 32	2 bergs.
5	105	do	44 43	48 47	Do.
5	106	do	44 14	48 44	Large berg.
5	107	Peoria	45 14	48 00	Small berg, several growlers.
5	108	do	45 09	48 30	Heavy field ice, growlers, 2 bergs.
5	109	Kerhonkson	44 03 to 43 49	48 10 to 48 36	1 berg, numerous growlers.
5	110	Cairnmona	44 33	48 17	2 large bergs.
5	111	do	44 32	48 23	Berg and growlers.
5	112	do	44 33	48 26	Do.
5	113	do	44 03 to 43 47	48 29 to 49 15	Several bergs and growlers.
6	114	New York City	43 58	49 16	Large berg.
6	115	Manchester Corporation	43 05	49 25	Small berg.
6	116	do	42 58	49 21	Growler and small pieces.
6	117	do	43 00	49 06	Very large berg.
6	118	Santa Inez	44 25	47 45	Small berg.
6	119	do	44 13	48 00	Several growlers.
6	120	do	44 08	48 06	Berg.
6	121	do	43 55	48 18	Very large berg, several more bergs to northward.
6	122	New York City	43 47	48 48	Large berg.
6	123	do	43 42	49 10	Small berg.
6	124	Ice patrol	43 00	49 15	Berg, same as 115.
6	125	do	43 05	49 25	Small berg and growler.
6	126	do	42 54	49 19	Growler.
6	127	do	42 44	49 39	Growler and small pieces.
6	128	Melmore Head	44 00	48 10	2 large bergs, same as 121.
6	129	do	43 45	48 20	Berg, same as 121.
6	130	do	43 42	48 30	Berg and growlers.
6	131	do	43 38	49 38	Berg.
6	132	do	43 46	49 00	Do.
6	133	Pere Pierre	43 12 to 44 35	48 10 to 48 00	15 bergs.
7	134	Topdalsfjord	44 58	48 50	Berg.
7	135	do	45 10	48 08	Berg and growlers.
7	136	do	45 16	48 05	Small berg.
7	137	Ice patrol	42 56	49 10	Berg, same as 124.
7	138	do	43 33	48 39	Berg, same as 131.
7	139	do	43 41	48 27	Berg, same as 130.
7	140	Topdalsfjord	45 12 to 45 20	47 53 to 47 10	Several growlers and small pieces.
7	141	Dutchess of York	42 46	49 20	2 growlers and several pieces of ice.
8	142	Canadian Inventor	44 12	47 42	Small berg, same as 118.
8	143	do	44 14	48 06	Large berg.
8	144	do	44 12	48 15	2 large bergs, same as 80.
8	145	Ice patrol	42 38	49 29	Berg with growlers to northward.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Apr. 8	146	Ice patrol	42 50	49 07	Large growler.
8	147	Emanuele Ackame	46 00	45 57	Small berg.
8	148	do	46 02	45 59	Large berg and growlers.
8	149	Consul Corfitzon	44 03	46 02	Growler.
8	150	do	44 05	46 15	Small berg.
8	151	do	43 59	46 18	Berg.
8	152	Emanuele Ackame	45 48	47 00	Berg and growlers.
9	153	City of Fairbury	42 43	49 30	Small berg, same as 145.
9	154	Athenia	43 13	49 07	Small berg.
9	155	Carmia	43 17	49 16	Berg.
9	156	Cameronia	42 25	49 34	Small berg.
9	157	Commercial Trader	42 30	49 29	Do.
9	158	do	42 23	49 29	Small berg, same as 156.
9	159	Sparreholm	43 49	46 18	Small berg, same as 150.
9	160	De Grasse	42 22	49 32	Growler, same as 158.
9	161	London Merchant	42 37	49 11	Berg and growler.
9	162	Commercial Trader	42 41	49 02	Large berg and 5 growlers.
9	163	Grey County	44 18	46 40	Berg.
9	164	Kolsnaren	46 00	45 30	3 large growlers.
9	165	Athenia	43 26	48 06	2 bergs, same as 133.
9	166	do	43 32	47 44	Berg.
10	167	Hada County	43 53	48 40	Do.
10	168	Grey County	42 52	49 52	Very large berg.
10	169	United States	42 20	49 43	Small berg.
10	170	Newfoundland	45 56	45 58	Medium-sized berg, same as 147.
7	171	Arlington Station	44 20	59 56	Broken mast projecting 7 feet.
10	172	Canadian Hunter	43 33	48 11	Small berg large growler.
10	173	Newfoundland	45 51	46 10	Medium berg and growler.
10	174	do	45 43	46 18	Large berg, growlers to north.
10	175	do	45 40	46 34	Large berg.
10	176	do	45 38	46 38	Do.
10	177	do	45 31	46 54	Do.
11	178	do	45 09 to 45 09	47 45 to 47 52	4 large bergs.
11	179	do	45 09	48 16	Large berg.
11	180	do	44 53	48 38	Field ice, numerous bergs and growlers for 33 miles to the north-northeast.
11	181	do	44 33	48 45	Growlers and field ice to northward.
11	182	Ice patrol	42 13	49 33	Small berg.
11	183	Caledonia	42 33	49 04	Large berg.
11	184	Oscar II	43 55	48 30	Do.
11	185	do	44 12	48 35	Do.
11	186	do	44 12	49 02	Do.
12	187	Scythia	44 16	48 49	Berg.
12	188	do	44 14	48 46	Field ice and growler.
12	189	Cape Race Station	42 37	48 34	French fishing vessel Sylvana abandoned on fire.
12	190	Malmen	42 20	49 16	Small berg.
12	191	Gripsholm	45 10	46 17	Large berg.
12	192	do	44 55	46 17	Berg 160 feet high.
12	193	do	44 52	46 28	Berg.
12	194	Whale	43 25	48 13	Berg, same as 172.
12	195	Ice patrol	42 34	48 52	Berg.
12	196	Whale	43 43	48 00	2 small bergs.
12	197	Gripsholm	44 40	47 10	Berg.
12	198	Bloomserdyk	40 32	49 42	Large tree, dangerous to navigation.
12	199	Gripsholm	43 45	48 11	Berg.
12	200	do	44 25 to 44 12	47 48 to 48 20	Numerous growlers.
12	201	Nova Scotia	44 05 to 44 15	48 45 to 48 18	3 bergs, 1 growler.
13	202	Ice patrol	42 32	48 38	Berg, same as 195.
13	203	Airthria	45 10	46 50	Berg.
13	204	do	44 51	47 30	3 bergs.
13	205	do	45 13 to 44 30	46 50 to 48 06	Numerous growlers.
13	206	do	44 21	48 22	2 bergs.
13	207	do	44 30	48 29	Berg.
12	208	Malmen	42 37	48 19	French fishing vessel Sylvana badly burnt and abandoned in sinking condition.
14	209	Kiel	44 29	45 57	Berg 100 meters high and 400 meters long.
14	210	Ice patrol	43 10	49 45	Small patches of sludge ice.
14	211	Canadian Planter	45 47	48 33	Bergs.
14	212	do	45 50	48 28	Berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Apr. 14	213	Canadian Planter	46 00 to 46 05	48 48 to 48 20	5 bergs.
14	214	do	45 53	48 20	Large berg.
14	215	do	45 55 to 46 15	48 20 to 47 37	Light scattered field ice on Track "E" becoming closely packed and heavy to southward.
14	216	do	46 15	47 35	Loose scattered ice north and south of Track "E," heavy field ice along edge of Banks.
15	217	Ice patrol	42 16	51 03	Berg with growler 5 miles to southeast.
15	218	do	42 08	50 52	Growler.
16	219	Beaver Hill	43 16	46 26	Large berg.
16	220	Kearny	43 47	45 45	Berg.
16	221	Passat	43 17	45 27	Large berg.
17	222	Quaker City	43 38	48 47	Do.
17	223	Hellig Olaf	42 53	46 05	Do.
17	224	Seattle Spirit	42 08	51 00	Berg, same as 217.
17	225	Boschdyk	42 04	51 00	Do.
17	226	Hellig Olaf	43 25	45 33	Large berg.
17	227	do	43 30	45 35	2 bergs, 1 growler.
17	228	do	43 30	45 10	Berg.
17	229	Stavangerfjord	44 23	44 06	Small berg and growlers.
18	230	Antonia	45 49 to 45 54	48 55 to 48 37	4 bergs.
18	231	do	45 58	48 33	Extensive field of ice.
18	232	do	45 54 to 46 08	48 31 to 48 28	Pack ice extending as far north and south as could be seen.
18	233	Frederick VIII	42 58	44 47	Berg.
18	234	do	42 58	45 35	Berg and growler.
18	235	California	43 02	45 01	Growler.
18	236	Frederick VIII	42 41	45 11	2 small bergs.
18	237	Antonia	45 23	48 34	Edge of field ice extending north and south.
18	238	Winona County	43 04	43 49	Large berg.
18	239	Cedric	46 28	48 23	Field ice.
19	240	do	46 35	48 26	3 large bergs, also much field ice.
19	241	Pennland	46 44	48 12	Field ice all around.
19	242	do	46 34 to 46 45	47 55 to 48 10	Some small ice, not dangerous.
19	243	Antonia	45 33	49 11	Field ice.
19	244	Cedric	46 09	49 08	4 bergs, many growlers.
19	245	Caronia	45 40	47 53	3 bergs.
19	246	do	45 15	48 06	Much field ice to northwest and southwest.
19	247	Antonia	45 24	28 55	Many bergs, field ice to the south and east.
19	248	Salacia	47 49	48 15	Isolated pieces of field ice.
19	249	Pennland	46 44	48 30	Heavy drift ice.
19	250	do	46 18	49 58	Several large bergs.
19	251	do	46 50 to 46 50	48 24 to 48 36	Very heavy pack ice, numerous growlers, several bergs.
19	252	do	46 50	48 24	Large patches light field ice to east.
19	253	Antonia	45 18	48 57	Western edge of ice pack.
19	254	Egham	46 41 to 46 36	48 00 to 48 17	Field ice with bergs and growlers.
19	255	Montcalm	46 30	49 00	Field ice.
19	256	Caronia	44 45	48 32	Southern end of field ice.
19	257	Egham	46 00	49 18	Large bergs—3 to north, 1 to west.
19	258	Cape Race Station	43 40	51 15	French sailing vessel Eskualduna abandoned in sinking condition.
19	259	do	46 35 to 45 58	48 26 to 49 27	4 bergs, numerous growlers.
19	260	Salacia	47 54	49 19	Field ice and several bergs to north and south.
20	261	West Arrow	44 38	47 17	Small berg.
19	262	Amasiddei	42 11	43 51	Log 1 foot diameter, 16 feet long with bolts.
20	263	West Arrow	43 44	49 14	Small field ice.
20	264	Antonia	44 42	48 23	Berg.
20	265	do	44 34	48 18	Large berg.
20	266	do	44 39	48 23	Several growlers.
20	267	do	44 46	48 10	Large berg.
20	268	do	44 33	48 10	Do.
20	269	Tyrifjord	44 42	48 38	Several bergs and growlers.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Apr. 20	270	Tyrifjord	45 32 to 45 03	49 11 to 49 18	Field ice with growlers.
20	271	do	45 03 to 44 46	49 18 to 49 04	Do.
20	272	Canadian Aviator	43 30	48 50	Small berg.
20	273	do	43 31	48 45	String of open field ice ½ mile wide.
20	274	Montcalm	46 18	49 45	Berg, same as 250.
21	275	Antonia	45 29	45 17	Small berg.
21	276	Melita	44 15	48 40	2 growlers.
21	277	Surichco	42 34	50 36	Large berg.
21	278	Stockwell	45 20	48 55	Field ice.
21	279	Melita	44 27	48 17	Small berg.
21	280	do	44 27	47 52	Large berg.
21	281	Stockwell	44 44	48 44	Do.
21	282	Cornerbrook	47 45 to 47 03	49 13 to 52 10	Field ice, heavy at times; numerous growlers and bergs.
21	283	Stockwell	44 44	48 03	2 bergs.
21	284	Bannack	44 39	48 46	Large berg.
21	285	do	44 24	48 31	Low-lying berg.
21	286	Montrose	43 23	48 46	Flat berg with growlers.
22	287	do	43 33	47 31	Large growler.
22	288	Ice patrol	43 03	50 37	Berg.
22	289	do	43 00 to 42 47	50 36 to 50 33	5 bergs; dozens of growlers.
22	290	Estonia	47 10	48 15	Open drifting pack with growlers.
22	291	do	47 10	48 30	Large berg.
22	292	do	47 03	48 35	Large berg 250 feet high.
22	293	do	46 53	48 43	Large berg.
22	294	Ice patrol	42 41	50 41	Berg.
22	295	Estonia	46 41	49 10	Large berg.
22	296	do	46 35	49 23	Do.
22	297	do	46 35	49 41	Small berg.
22	298	do	46 29	49 46	Do.
22	299	do	46 24	49 42	Large berg surrounded by growlers.
22	300	Melmore Head	43 08	51 10	Large berg.
22	301	do	43 08 to 43 08	51 38 to 51 10	Pieces drift ice and growlers.
24	302	Dutchess of York	47 19 to 46 25	47 33 to 48 41	Many dangerous growlers and scattered pieces.
24	303	Montclare	46 20 to 46 14	48 34 to 48 45	Field ice, low bergs, and growlers stretching to south-southwest.
24	304	do	46 27	48 17	Field ice.
24	305	do	46 07	49 20	Growlers.
24	306	Ice patrol	42 53 to 42 51	50 56 to 50 23	3 bergs, 3 growlers.
24	307	Oscar II	46 13 to 46 18	48 36 to 48 16	Numerous growlers and bergs, field ice.
24	308	Brandon	46 55 to 46 08	47 25 to 48 34	Numerous bergs, growlers, field ice, and heavy rafts.
25	309	Columbialite	47 00	48 00	Numerous growlers.
25	310	Regina	47 08 to 47 01	47 20 to 47 44	Field ice and growlers. Field ice, low lying and breaking up.
25	311	do	46 46	48 05	Berg.
25	312	Cairnglen	47 54 to 48 12	50 40 to 50 42	Numerous bergs and growlers.
25	313	Regina	46 44	48 20	Small berg.
25	314	Ascania	46 25	47 55	Numerous growlers in vicinity.
25	315	Minnedosa	47 18 to 47 07	47 10 to 47 36	Numerous growlers and large pieces of ice.
25	316	Cape Race Station	47 19 to 46 10	47 33 to 48 50	Open field ice.
25	317	do	47 50 to 48 20	50 25 to 49 00	Numerous bergs and growlers with strings of heavy field ice to northeast.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
Apr. 25	318	Minnedosa	47 07 to 46 54	47 36 to 47 52	Patches and strips of field ice and growlers to north and south of track as far as could be seen.
25	319	do	46 49	48 06	Large berg.
25	320	do	46 42	48 18	Berg and growlers.
26	321	Coelleda	43 48	45 10	Small berg.
26	322	Jeanne d'Arc	45 35	48 30	Berg, broken ice.
26	323	Beaverbrae	46 34	48 04	Berg.
26	324	do	48 38 to 46 34	47 51 to 48 04	Heavy open field ice.
26	325	Athenia	45 00 to 45 00	48 18 to 48 44	Pieces of ice.
26	326	Coelleda	43 25	46 00	Large growlers.
26	327	Calgaric	46 55	47 11	Several growlers.
26	328	do	47 00 to 46 30	48 01 to 48 11	Do.
26	329	do	46 32	48 01	Berg.
26	330	do	46 42	47 55	Do.
27	331	Cape Race Station	48 05 to 48 00	47 35 to 48 07	Field ice growlers and numerous bergs.
26	332	do	47 05 to 46 54	47 39 to 47 31	Patches and strips of field ice and growlers.
27	333	do	47 38 to 47 25	48 35 to 50 06	Scattered growlers and small bergs.
26	334	do	47 15	50 00	6 growlers.
27	335	do	46 50 to 46 30	47 16 to 48 11	Small pieces and growlers.
26	336	do	48 20 to 47 45	50 00 to 48 51	Heavy field ice.
26	337	do	47 45 to 47 30	48 51 to 49 10	Numerous bergs and growlers.
27	338	West	41 30	47 19	Spar, 3 feet long, standing upright.
27	339	Cape Race Station	47 56	48 26	Large berg 160 feet high 440 feet long.
27	340	do	46 59	47 07	Small growler, same as 327.
27	341	do	46 50	47 16	2 growlers.
28	342	Argosy	47 22	42 35	Spar projecting 6 feet out of water apparently attached to submerged wreckage.
28	343	Capulin	42 03	65 48	Red gas buoy marked "H," light burning.
28	344	Laval County	47 00 to 46 40	47 00 to 48 00	Numerous growlers and small pieces.
28	345	do	46 38	47 46	Large berg.
28	346	do	46 28	48 18	Small berg.
28	347	Cape Race Station	47 30	46 50	Several growlers.
28	348	do	47 30 to 46 52	46 44 to 47 10	Heavy open field ice and numerous heavy growlers.
28	349	do	46 52 to 46 17	47 10 to 47 40	Several growlers.
28	350	do	46 40	48 00	Large berg.
29	351	West Noska	42 52	50 45	3 bergs.
29	352	Cape Race Station	46 45	47 08	Small berg and several growlers.
May 1	353	Newfoundland	48 23 to 48 16	50 33 to 50 44	Numerous growlers and pieces of field ice.
Apr. 30	354	Cape Race Station	48 09	51 00	Large berg.
May 1	355	Ice patrol	43 07	50 52	Berg and growlers.
1	356	New York City	43 22	50 10	3 bergs many small pieces.
Apr. 30	357	Cape Race Station	48 50	49 46	Berg and growlers, field ice to southwest.
May 1	358	Airthria	45 35	48 39	Berg.
1	359	do	45 41	48 26	Do.
1	360	do	45 36	48 25	Growlers.
1	361	do	45 45	48 08	Berg.
1	362	do	45 49	47 59	Do.
1	363	do	46 01	47 20	2 bergs several growlers.
1	364	do	45 56	47 06	2 growlers.
1	365	New York City	43 54	48 35	Large berg.
1	366	Montroyal	47 10	47 12	Growler.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 1	367	Montroyal	47 09	47 16	Growler.
1	368	do	47 01	47 13	Large berg, numerous growlers.
1	369	Far North	45 34	48 43	Large berg, same as 358.
1	370	Montroyal	47 12	47 31	Large berg.
1	371	do	46 59	47 22	Medium berg.
1	372	do	47 04 to 46 55	47 27 to 47 50	Numerous bergs and growlers.
1	373	do	46 54	47 49	Large berg.
1	374	do	46 51	47 41	Berg.
1	375	do	46 42	48 09	Growlers.
1	376	Beaverdale	46 30	48 01	Growlers to the northeast.
2	377	Ice patrol	43 11	50 10	2 bergs.
2	378	do	43 05	49 47	Growler.
2	379	Lehigh	45 01	48 16	Berg.
2	380	do	45 00	48 33	Do.
2	381	Laurentic	47 03	47 25	Growler.
2	382	do	47 01	47 29	Do.
2	383	do	46 41	47 49	2 large bergs, same as 372.
2	384	Ice patrol	43 04	49 40	Growler.
1	385	Cape Race Station	44 52	49 32	Low-lying berg.
2	386	do	47 24	47 12	Large berg.
2	387	do	47 16	47 11	Small growler.
2	388	do	46 40	47 40	Berg.
2	389	do	46 41	47 49	2 small bergs, same as 372.
1	390	do	45 34	46 43	Large berg.
2	391	Kentucky	45 53	47 38	Growler.
2	392	do	45 53	47 41	Do.
2	393	do	45 49	47 59	Berg.
2	394	do	45 32	48 22	Large berg.
2	395	do	45 32	48 25	Growler.
2	396	do	45 30	48 37	Large berg, same as 359.
2	397	Alaunia	47 00	46 41	Berg.
2	398	do	46 42	47 04	Growlers.
2	399	do	46 43	47 07	Large berg.
2	400	do	46 40	47 16	Growlers.
2	401	Ice patrol	43 40	48 30	Berg.
2	402	do	43 42	48 19	Do.
2	403	do	44 05	48 35	Do.
2	404	Arabic	46 54	47 11	1 large, 2 small, low-lying bergs.
2	405	do	46 53	46 47	Small berg.
2	406	do	46 46	47 35	Large low-lying berg.
2	407	do	46 39	47 43	2 bergs, several growlers.
2	408	Estonia	47 23	47 52	Growler.
2	409	do	47 30	47 53	Berg.
2	410	do	47 25	47 37	Growler.
2	411	do	47 28	47 41	Large berg.
2	412	do	47 36	47 49	Small berg.
2	413	do	47 33	47 41	Growler.
2	414	do	47 34	47 36	Do.
2	415	do	47 37	47 34	Do.
2	416	do	47 36	47 29	Do.
2	417	Norefjord	48 02 to 48 35	49 11 to 48 15	Field ice, small bergs, and growlers to northwest.
1	418	do	48 35 to 48 11	48 15 to 48 54	Do.
1	419	Cairnross	48 45 to 48 40	49 40 to 49 25	Field ice to westward heavy in places and containing bergs and growlers.
1	420	do	48 40 to 48 15	49 25 to 48 20	Do.
1	421	do	48 30 to 47 50	48 20 to 48 20	Several bergs and growlers.
2	422	Hjelmaren	48 46 to 48 30	46 52 to 47 54	Drift ice with about 100 growlers and 20 bergs.
2	423	do	48 28	48 00	Berg.
2	424	do	48 25	48 01	Do.
2	425	do	48 24	48 05	Do.
2	426	do	48 23	48 06	Do.
2	427	do	48 22	48 08	Do.
2	428	do	48 24	48 14	Berg 100 feet high.
2	429	do	48 19	48 26	Berg.
2	430	do	48 18	48 36	Large berg and growler.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
May 2	431	Hjelmaren	48	11	48	31	Large berg.
2	432	do	48	14	48	42	Do.
2	433	do	48	11	48	44	Pyramidal berg 155 feet high.
2	434	do	48	10	48	49	Large berg.
2	435	Carmia	47	24	47	07	Berg and growlers.
2	436	do	47	22	47	18	Growler.
2	437	Kentucky	45	41	50	21	Spar projecting 6 feet, apparently attached to submerged wreckage.
3	438	Albertic	47	24	46	54	Growlers.
3	439	do	47	24	47	06	Berg.
3	440	do	47	17	47	11	Do.
3	441	do	47	18	47	16	Do.
3	442	do	47	14	47	19	Do.
3	443	do	47	18	47	19	Do.
3	444	Ice patrol	43	56	48	48	Berg, same as 403.
3	445	do	43	50	49	21	Berg.
3	446	Eberstein	48 45 to 49 00		49 00 to 48 22		Fields of growlers.
3	447	Ice patrol	43	34	50	04	Berg.
3	448	do	43	28	50	10	Berg and growlers.
3	449	do	43	25	50	08	Low-lying berg.
3	450	do	43	15	50	38	Berg.
3	451	Eberstein	48	00	50	10	Field of heavy growlers and several bergs.
2	452	Cape Race Station	47	53	49	00	Berg.
2	453	do	47	50	49	02	Do.
2	454	do	47	52	49	03	Do.
2	455	do	47	48	49	00	Do.
2	456	do	47	48	49	05	Berg 600 feet long and 40 feet high.
4	457	Montclare	46	51	57	11	Patches of scattered field ice.
4	458	(IIBC)	41	27	54	48	Red buoy marked "2 AF" projecting about 6 feet.
5	459	Ice patrol	43 24 to 43 28		49 04 to 48 33		4 bergs, several growlers.
5	460	do	43	47	48	42	Small berg.
5	461	Montclare	46	49	47	25	Medium berg.
5	462	do	46	53	47	24	Do.
5	463	do	46	54	47	20	Very large berg.
5	464	do	46	44	47	20	2 low-lying medium bergs.
5	465	Lord Downshire	47	14	46	34	Small berg.
5	466	do	47	10	46	37	Berg and several pieces.
5	467	Ice patrol	43	45	49	17	Small berg.
5	468	Montclare	46	55	47	05	Berg.
5	469	do	46	44	46	56	Very large berg.
5	470	do	47	06	46	05	Small growlers.
5	471	Lord Downshire	47	03	47	14	Berg.
6	472	Vallemare	45	08	46	51	Small berg.
6	473	O. A. Larsen	43	02	48	50	Large berg, same as 459.
6	474	do	43	19	48	35	Do.
6	475	Lord Downshire	46	48	47	30	Large berg 160 feet high.
6	476	do	46	50	47	40	Small low berg and several growlers.
5	477	Cape Race Station	46	52	47	30	Growler.
6	478	Ice patrol	43	04	48	49	Berg, same as 473.
6	479	Vallemare	45	11	47	12	Small berg.
6	480	Keret	46	12	47	42	2 bergs.
6	481	Vallemare	45	17	48	23	Berg and 2 growlers.
6	482	Calgaric	46	12	47	33	Berg.
6	483	do	46	16	47	41	Low berg, same as 480.
6	484	do	46	11	47	32	Growler.
6	485	do	46	12	47	28	Do.
6	486	Cairnes	47	19	46	33	Small berg and numerous pieces.
6	487	Calgaric	46	05	47	13	Berg.
6	488	do	46	15	47	07	Growlers.
6	489	do	46	09	47	11	Do.
6	490	do	46	13	46	56	Large bergs.
6	491	do	46	26	46	55	Berg.
6	492	do	46	12	46	43	Do.
6	493	do	46	29	46	27	Large berg.
6	494	do	46	22	46	21	Berg.
6	495	do	46	29	46	24	Do.
6	496	do	46	11	46	28	Large berg.
6	497	Nieu Amsterdam	46	35	46	25	Small berg and growlers.
6	498	do	46	30	46	44	Large berg and several growlers.
7	499	do	46	22	47	10	Large berg and growlers.
7	500	Ascania	46	16	47	08	Large berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 7	501	Brighton	46 30 to 46 30	46 30 to 47 20	Numerous growlers and 1 large berg.
7	502	Vulcania	40 31	44 55	Red iron cylinder 40 feet long 6 feet high.
7	503	Athenia	47 11	47 05	Scattered growlers and heavy pieces of field ice.
7	504	Flensburg	47 44 to 47 40	47 12 to 47 25	Numerous growlers and scattered pieces of ice.
7	505	do	47 40 to 47 30	47 25 to 47 25	Eastern edge of field ice and growlers impossible to cross; 1 berg seen in field.
7	506	do	47 30 to 47 30	47 25 to 47 35	Field ice and growlers.
7	507	do	47 38	46 04	Berg.
7	508	do	47 40	46 27	Berg and growlers.
7	509	Arizpa	40 38	42 36	Spar floating upright projecting 5 feet apparently attached to submerged wreckage.
7	510	do	40 38	42 34	Log about 15 feet long.
7	511	Flensburg	47 20	47 36	15 bergs and numerous growlers.
7	512	Regina	46 43	47 19	Berg.
7	513	do	46 20	47 45	Growler and small pieces.
7	514	do	46 40 to 46 43	47 29 to 47 19	1 small berg several growlers.
8	515	Flensburg	47 20 to 47 20	47 36 to 48 15	2 bergs numerous growlers.
8	516	Regina	46 44	47 21	Large berg, several growlers.
8	517	Minnedosa	47 23	46 58	Medium berg.
8	518	do	47 26	46 50	Large berg and 3 growlers.
8	519	do	47 22	47 00	Berg.
8	520	do	47 29	46 44	2 bergs, 2 growlers.
8	521	do	47 33	46 36	Field ice stretching east and west 5 miles, 1 berg, and numerous growlers.
8	522	Flensburg	47 56	49 19	8 large bergs.
8	523	do	47 58	48 56	2 very large bergs.
8	524	do	48 00	49 56	Large berg.
8	525	Minnedosa	46 27	46 47	Do.
8	526	Aurania	46 12	47 29	Low berg.
9	527	do	46 10 to 46 03	47 32 to 47 44	5 small growlers.
9	528	do	46 04	47 43	Small berg.
9	529	Dutchess of Richmond	44 00	48 49	Do.
9	530	Doric	47 29	46 35	Bergs and numerous growlers, same as 521.
9	531	do	47 25	46 44	Large berg, may growlers, same as 520.
9	532	Melita	47 06	57 05	Several small pieces of field ice.
9	533	Flensburg	47 56 to 47 56	49 19 to 49 54	Numerous bergs.
9	534	Dubhe	48 10 to 48 03	47 00 to 47 53	7 bergs, many growlers, much field ice.
9	535	Doric	47 25 to 47 11	46 44 to 47 19	Several large bergs and many growlers.
9	536	Montrose	46 54 to 47 11	47 08 to 46 23	Numerous pieces of ice.
9	537	Megantic	46 59	46 39	1 growler, several pieces.
9	538	do	46 55	46 49	1 small berg.
9	539	Beaverbrae	45 59	48 13	Large berg 300 feet high.
9	540	do	46 02	47 52	Large berg, 4 growlers.
9	541	do	46 02	47 49	Small berg, 6 growlers.
9	542	do	46 06	47 40	Large, low berg.
9	543	Letitia	47 31	45 05	Growlers.
9	544	do	47 35 to 47 23	45 53 to 46 10	Field ice, growlers, and heavy broken pieces.
9	545	Salacia	45 51	48 06	Large berg and several growlers.
9	546	Dutchess of Richmond	44 57	44 55	Berg 100 feet high.
9	547	Heronspool	45 41	47 24	Small berg.
9	548	Flensburg	47 56 to 48 18	49 54 to 51 02	8 large bergs and some growlers.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 9	549	Beaverbrae	46 23	46 45	Berg.
9	550	Letitia	47 20	46 23	Do.
9	551	do	47 03	46 40	Growler.
10	552	Empress of Scotland	46 18	47 40	Small growlers.
10	553	Ice patrol	43 14	49 21	Berg.
10	554	Melita	47 28	46 34	Several growlers and small pieces.
10	555	do	47 26 to 47 20	46 37 to 46 50	Open field ice and growlers.
10	556	Empress of Scotland	46 35	46 44	Large berg with numerous growlers.
10	557	Sagauche	43 00	49 20	Berg, same as 560.
10	558	Malmen	45 50	44 47	Berg and 4 growlers.
10	559	Perseus	43 34	47 52	Large berg.
10	560	Ice patrol	42 59	49 20	Berg, same as 553.
10	561	Salacia	45 51 to 46 14	47 43 to 46 43	5 bergs and several growlers.
10	562	do	46 20 to 46 42	46 13 to 45 10	Several growlers.
10	563	Cape Race Station	47 34 to 47 11	46 24 to 47 19	Numerous bergs and many growlers.
10	564	Beaverford	46 51	46 45	Berg.
11	565	do	46 54	46 46	Large berg.
11	566	do	46 47	46 54	Berg.
11	567	Barom Elibank	47 25 to 47 00	45 55 to 47 00	13 large bergs and several growlers.
10	568	Cape Race Station	47 03	46 45	Growler.
11	569	Wytheville	42 03	45 16	Large spar projecting 3 feet out of water apparently attached to submerged wreckage.
11	570	Vallarparosa	43 43	48 41	Large berg.
11	571	do	43 56	49 04	Small berg.
11	572	Humber Arm	48 45	49 00	Field ice running north and south, also 2 bergs.
11	573	Vallarparosa	43 30	47 50	2 bergs and growlers.
11	574	Humber Arm	48 45 to 48 29	49 00 to 49 33	18 large bergs.
11	575	Nevisian	48 29	44 15	Small berg and growler.
11	576	Vallarparosa	44 06	49 33	Small berg.
11	577	Flensburg	48 18 to 47 50	51 02 to 52 45	10 bergs.
11	578	Humber Arm	48 38	49 15	Field ice.
11	579	do	48 17	50 07	Berg.
11	580	do	48 21	50 14	Do.
11	581	do	48 10	50 35	Do.
11	582	Nevisian	48 19	44 49	Growler.
12	583	do	47 45	45 50	Growlers and field ice.
12	584	do	47 36	45 58	Berg on southern end field ice.
12	585	do	47 39	45 58	Do.
12	586	Concordia	47 40 to 47 38	45 46 to 46 05	Detached growlers and small pieces of ice.
12	587	Nevisian	47 32	45 58	3 bergs.
12	588	do	47 17	46 18	5 growlers.
12	589	do	47 18	46 20	Berg.
12	590	do	47 17	46 43	Do.
12	591	Ice patrol	42 46	49 55	Berg, same as 553.
12	592	Concordia	47 38 to 47 22	46 05 to 46 47	Small bergs and growlers on each side o track.
12	593	do	47 22 to 47 05	46 47 to 47 00	Numerous bergs and growlers mostly north of track.
12	594	Nevisian	47 13 to 47 00	46 43 to 47 18	8 large and 4 small bergs, also 4 growlers.
12	595	Bothwell	46 12	48 07	Berg.
12	596	do	46 07	48 02	Do.
12	597	do	46 18	47 40	Do.
12	598	do	46 29	47 02	Do.
12	599	do	46 37	46 54	Do.
12	600	do	46 32	46 53	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north (° ′)	Position: Longitude west (° ′)	Nature of ice or obstruction
May 12	601	Kastalia	47 02 to 46 42	46 10 to 47 11	8 bergs and 8 growlers and small pieces.
12	602	Concordia	47 05	47 22	Berg.
12	603	Cape Race Station	46 57 to 46 43	46 17 to 47 07	8 large, 6 small bergs, and 12 growlers, same as 567.
12	604	Bothwell	46 35	46 27	Berg.
12	605	do	46 44	46 26	Do.
12	606	do	46 53	45 52	Do.
12	607	do	46 52	45 49	Growlers.
13	608	Mount Royal	46 22	48 03	Berg.
13	609	Hardenberg	44 52	45 00	Do.
13	610	Laponia	49 00 to 48 50	49 50 to 50 10	Numerous growlers and heavy field ice.
13	611	do	48 45 to 48 36	50 28 to 50 50	Several bergs and growlers.
13	612	Montroyal	47 09	46 35	1 large, 1 small berg with growlers, same as 567.
13	613	Laponia	48 46	50 30	Large berg.
13	614	Montroyal	47 23	46 05	Berg and growler, same as 592.
13	615	Federal	32 57	47 15	3-masted derelict schooner Quaco Queen, bowsprit and about 40 feet of mizzenmast standing.
13	616	Ice patrol	42 48	50 47	Berg, same as 553.
13	617	Nova Scotia	48 52	44 42	Growler.
13	618	Andania	46 49	46 59	Berg, same as 594.
13	619	do	46 58	46 36	Small berg, same as 594.
13	620	Nova Scotia	48 36	45 24	Several small growlers.
14	621	Andania	47 22	45 43	Growlers.
14	622	Nova Scotia	48 23	46 05	Berg.
14	623	do	48 20	46 07	Growlers.
14	624	do	48 20	46 15	Do.
14	625	do	48 15	46 19	Large berg.
14	626	do	48 13	46 31	Do.
14	627	do	48 09	46 34	Small berg and growlers.
14	628	do	48 08	46 52	Small berg.
14	629	Veendam	47 08	45 12	Growler.
14	630	do	47 04	45 22	Small berg.
14	631	Cape Race Station	46 39	45 43	Large berg, same as 634.
14	632	do	46 42	45 42	Large berg and many small pieces.
14	633	Nova Scotia	47 44 to 47 40	47 23 to 46 41	8 bergs and 2 growlers.
14	634	Veendam	46 35 to 46 50	46 53 to 46 53	9 bergs and 4 growlers.
14	635	Nicoline Maersk	41 28	45 00	Log 40 feet long 12 inches square.
14	636	Nova Scotia	47 42	47 45	Berg.
14	637	Laurentic	46 26 to 47 12	47 44 to 46 24	24 bergs and growlers on both sides of track.
14	638	Veendam	46 10 to 45 40	46 53 to 48 08	7 large bergs, same as 539–542.
14	639	Hardenberg	44 45	47 53	Growler.
14	640	Laurentic	47 12 to 47 45	46 24 to 45 34	4 bergs and numerous growlers.
14	641	do	48 00	44 55	Growler.
14	642	do	47 56	44 37	Small berg and growler.
15	643	Polonia	46 07	47 51	Berg.
15	644	do	46 19	47 53	Berg 50 feet high.
15	645	Ice patrol	42 21	50 50	Berg, same as 616.
15	646	Hardenberg	44 48	48 31	Medium berg.
15	647	Polonia	46 34	47 30	Berg, same as 637.
15	648	do	46 31	47 08	Do.
15	649	do	46 33	47 04	Do.
15	650	do	46 35	46 56	Do.
15	651	do	46 41	47 00	Do.
15	652	Kenmore	47 32 to 47 20	46 46 to 47 40	Numerous bergs, same as 637.
15	653	Polonia	46 40 to 47 05	47 10 to 46 05	20 bergs and growlers.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north ° ′	Position: Longitude west ° ′	Nature of ice or obstruction
May 15	654	Carmia	48 02	49 18	Berg.
15	655	do	48 06	49 15	2 bergs, numerous growlers.
15	656	do	48 14	48 57	Berg.
15	557	Carmia	48 14	48 48	Do.
15	558	do	48 17	48 44	Growlers.
15	659	do	48 37	47 56	Berg.
15	660	Cameronia	46 28	47 15	Small berg.
15	661	Hangirland	47 48	52 54	Large berg and several growlers.
15	662	Polonia	47 40	45 02	3 large and 3 small bergs and several growlers.
15	663	Cameronia	46 57	47 25	Large berg, same as 637.
15	664	do	46 36	46 48	Berg, same as 637.
15	665	do	47 00	47 00	Large berg, same as 637.
15	666	do	47 03	46 48	Do.
15	667	do	47 19	46 50	Do.
15	668	do	47 05	46 25	Small berg and growler, same as 637.
15	669	do	47 12	46 27	Berg, same as 637.
15	670	do	47 10	46 20	Do.
15	671	do	46 40	46 58	Low berg, same as 637.
15	672	do	46 47	46 40	Do.
15	673	do	46 59	46 58	Berg, same as 637.
15	674	do	47 00	46 48	Growler, same as 637.
15	675	do	47 08	46 30	Do.
15	676	do	47 05	46 22	Do.
15	677	do	47 00	46 18	Berg, same as 637.
15	678	do	47 10	46 12	2 bergs, same as 637.
15	679	do	47 18	46 05	10 bergs and numerous growlers within 10 miles radius, same as 637.
15	680	Cairnross	48 20	49 15	Small berg.
15	681	do	47 45 to 48 40	50 30 to 48 50	28 bergs and numerous growlers to southward.
15	682	Topsdalsfjord	48 45 to 48 10	48 15 to 50 15	Field ice for about 10 miles and then several large bergs and numerous growlers.
16	683	California	48 17	45 13	Small low berg.
16	684	do	48 03	44 48	2 bergs.
16	685	do	47 55	45 40	Do.
16	686	do	47 50	45 56	Berg.
16	687	do	47 46	45 55	Berg, same as 652.
16	688	do	47 38	46 30	Do.
16	689	do	47 29	46 42	Large berg, same as 652.
16	690	do	47 29	46 48	Large low berg, same as 652.
16	691	do	47 10	47 09	2 large bergs, same as 652.
16	692	do	47 30	46 37	7 bergs, same as 652.
16	693	do	47 12	47 07	4 bergs, same as 652.
16	694	Ausonia	48 42	44 30	Several growlers.
16	695	do	48 45	44 31	2 bergs.
16	696	Cameronia	47 30	45 38	Berg.
16	697	do	47 37	45 15	Small berg.
16	698	do	47 43	45 08	Do.
16	699	do	47 44	45 28	Growlers.
16	700	do	47 48	44 55	Large berg and growler.
16	701	Cairnross	48 20	49 15	Small ice field.
15	702	Cape Race Station	47 40	52 40	Berg aground.
16	703	Antonia	48 36 to 48 18	48 18 to 48 37	3 small bergs and line of growlers and small pieces of ice.
16	704	Beaver Hill	47 47	44 40	Berg.
16	705	do	47 41	45 12	Large berg and numerous pieces.
16	706	do	47 50	45 12	Berg.
16	707	do	47 48	45 30	Do.
16	708	do	47 37	45 41	Growlers.
16	709	Metagama	48 37	44 44	Berg.
16	710	do	48 34	44 56	Growler.
16	711	do	48 22	45 28	Large berg.
16	712	do	48 23	45 32	Do.
16	713	do	48 23	45 33	Berg.
16	714	do	48 26	45 38	Do.
16	715	do	48 22	45 48	Large berg.
16	716	do	48 23	45 48	3 growlers.
16	717	do	48 21	45 49	Growler.
16	718	do	48 20	45 50	Berg and pieces.
16	719	do	48 19	45 50	Berg.
16	720	Antonia	48 09	48 55	2 small bergs.
16	721	Ausonia	48 35	45 08	Berg.
16	722	do	48 34	45 38	2 growlers and 4 large pieces
16	723	do	48 30	45 45	3 growlers.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 16	724	Ausonia	48 24	45 49	2 small bergs.
16	725	do	48 26	45 53	1 berg.
16	726	do	48 26	46 00	1 berg, 1 growler, and several pieces.
16	727	do	48 21	46 03	1 growler.
16	728	California	48 21 to 46 57	45 29 to 47 45	8 bergs, 19 growlers, and numerous pieces.
16	729	Penland	47 06	45 26	Large berg, 3 growlers to eastward.
17	730	California	47 54	46 07	Large berg.
17	731	Penland	47 00	45 47	Do.
17	732	do	46 54	46 07	Do.
17	733	Beaver Hill	47 38	45 50	Do.
17	734	do	47 31	46 47	Berg.
17	735	Metagama	48 02	47 10	2 bergs.
17	736	do	47 58	47 30	Large berg.
17	737	do	47 51	47 45	Berg.
17	738	do	47 49	47 55	Numerous growlers.
16	739	do	48 21	45 49	Berg.
16	740	do	48 16	46 07	Large berg and growler.
16	741	do	48 10	46 20	Large berg.
16	742	do	48 06	46 34	Large low berg.
16	743	do	48 05	46 41	Large berg.
16	744	do	48 05	46 48	Medium berg.
16	745	do	48 06	46 55	Large berg.
16	746	do	48 04	46 55	Do.
16	747	do	48 03	47 01	2 bergs.
16	748	do	48 02	47 07	Berg.
16	749	do	47 58	47 20	Very large low berg.
16	750	Antonia	48 00	49 12	Growler.
16	751	do	47 58	49 14	Large berg.
16	752	do	47 57	49 22	Medium berg.
16	753	do	47 57	49 27	Large berg.
16	754	Ausonia	48 13	46 10	Growler.
16	755	do	48 12	47 26	Small bergs, numerous pieces.
16	756	do	48 10	46 40	1 large, 2 small bergs, and pieces.
16	757	do	48 08	46 50	Large berg.
16	758	do	48 05	47 00	Do.
16	759	do	48 07	47 08	Do.
16	760	do	48 05	47 13	2 large bergs.
16	761	do	48 03	47 20	Large berg and several growlers.
16	762	do	47 58	47 34	Large berg.
17	763	do	47 47	48 21	Do.
17	764	do	47 44	48 27	Do.
17	765	do	47 42	48 35	Do.
17	766	do	47 42	48 36	Small berg.
17	767	do	47 43	48 39	Large berg.
17	768	Metagama	47 35	48 40	Do.
17	769	do	47 40	48 50	3 bergs.
17	770	do	47 33	48 50	Berg.
17	771	Beaver Hill	47 22	48 31	Do.
18	772	Drottningholm	42 43	51 16	Large berg and several growlers.
18	773	Carlsholm	44 38	45 44	Large berg.
17	774	Cape Race Station	48 42 to 47 43	44 30 to 48 39	Numerous bergs and growlers and smal pieces of ice on both sides of track.
18	775	do	48 40	49 31	4 bergs and hundreds of growlers.
18	776	Ice patrol	42 47	50 49	Berg and growlers.
18	777	Spilsby	44 44	45 33	Berg.
18	778	Balsam	42 53	49 53	Large berg.
18	779	Cape Race Station	48 36	49 34	6 bergs.
18	780	Grandon	42 40	43 59	Log 3 feet diameter 20 feet long.
18	781	Firpark	45 55	45 34	Small berg and growler.
18	782	Balsam	42 44	50 54	Large berg same as 776.
19	783	Quaker City	42 48	50 22	Growler.
19	784	do	42 43	51 13	Berg and several growlers, same as 772.
19	785	Ice patrol	42 44	51 13	Berg, same as 772.
19	786	Henrik Ibsen	45 14	48 07	Berg.
19	787	Firpark	45 47	47 44	One high and one low berg.
19	788	Ice patrol	42 54	50 08	Berg.
19	789	Montrose	48 03 to 47 40	46 13 to 48 06	About 40 bergs on both sides of track.
19	790	Magantic	47 39	47 24	Berg.
19	791	do	46 56	46 19	Large berg.
19	792	do	48 02	45 38	Small berg and 4 growlers.
19	793	Montrose	47 58 to 48 17	46 39 to 45 00	6 bergs, numerous growlers.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 19	794	Montrose	48 11	45 20	Berg.
20	795	Magantic	48 15	44 44	Do.
20	796	Molita	47 53 to 48 11	49 59 to 49 17	8 bergs and several small pieces.
20	797	Aurania	47 43	48 24	Very large berg.
20	798	Seattle Spirit	45 23	45 40	Small berg.
20	799	Aurania	47 47	48 09	Large berg and growlers.
20	800	do	47 53	47 56	Do.
20	801	do	47 47	47 55	Do.
20	802	do	47 24	47 49	Do.
20	803	do	47 53	47 48	Do.
20	804	do	47 31	47 48	Do.
20	805	do	47 47	47 49	Do.
20	806	do	47 44	47 42	Do.
20	807	do	47 49	46 43	Large berg and growlers, same as 789.
20	808	do	47 46	46 40	Do.
20	809	do	47 49	46 35	Do.
20	810	do	47 54	46 33	Do.
20	811	do	47 59	46 32	Large berg, same as 789.
20	812	do	47 54	46 30	Small berg, same as 789.
21	813	Letitia	47 09	45 16	Berg.
21	814	do	47 17	44 57	Do.
21	815	do	47 27	44 19	Do.
21	816	do	46 45	46 26	2 bergs.
21	817	do	46 50	46 25	Large berg.
21	818	do	46 52	46 21	Berg.
21	819	do	46 52	46 10	Do.
21	820	do	47 07	45 49	Do.
21	821	do	46 25	47 37	Large berg.
21	822	do	46 37	47 30	Do.
21	823	do	46 27	47 00	Do.
21	824	do	46 32	47 10	Do.
21	825	do	46 40	47 00	Do.
21	826	do	46 40 to 47 00	46 45 to 46 30	8 bergs.
21	827	Aurania	48 03	45 44	Small low berg.
21	828	do	48 06	45 38	Growler.
21	829	Pajola	47 40 to 47 53	47 11 to 46 08	31 bergs close to track, same as 789.
21	830	Seattle Spirit	45 16	46 41	Berg.
21	831	Ice patrol	42 38	50 40	Small berg.
20	832	Cape Race Station	45 27	47 56	2 bergs.
20	833	do	47 44	52 10	Do.
20	834	do	47 51	52 13	Berg.
20	835	do	48 10	52 17	Do.
20	836	do	47 58	52 16	Do.
20	837	do	47 58	52 21	Do.
20	838	do	47 49	47 10	Growlers.
20	839	do	47 47	47 07	Do.
20	840	do	47 44	47 05	Do.
20	841	do	47 44	46 58	Do.
20	842	do	47 53	46 53	Do.
20	843	do	47 50	46 43	Large growlers.
20	844	do	47 36	46 41	Do.
20	845	do	47 49	46 35	Large growler.
20	846	do	47 54	46 33	Do.
20	847	do	47 59	46 32	Large berg.
20	848	do	47 54	46 30	Small berg.
21	849	Doric	47 55	49 50	Do.
21	850	do	47 58	49 43	Long, low berg.
21	851	do	47 59	49 41	Large berg and medium low berg.
21	852	do	48 00	49 32	Large berg and 2 growlers.
21	853	Coldilana	42 45	51 15	Large berg.
21	854	Doric	48 08 to 48 24	49 03 to 48 28	Large and medium bergs, many growlers on both sides of track.
21	855	do	48 24	48 28	Many bergs to northeastward.
21	856	Montcalm	48 10	46 45	Small berg, several growlers.
21	857	do	47 58	46 45	Large berg.
21	858	do	47 54	47 00	Do.
21	859	do	47 48	47 14	Do.
21	860	do	47 59	47 20	Small berg.
21	861	do	48 08	47 23	2 small bergs.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 21	862	Montcalm	48 02	47 25	Small berg.
21	863	do	48 02	47 26	Do.
21	864	do	47 50	47 27	Large berg.
21	865	do	47 56	47 27	Medium berg.
21	866	do	48 00	47 33	Large growler.
21	867	do	47 55	47 34	Large berg.
21	868	do	48 01	47 37	Do.
21	869	do	48 02	47 40	Berg and growlers.
21	870	do	47 48	47 42	Large low berg.
21	871	do	47 59	47 42	Small berg.
21	872	do	48 06	47 48	Berg.
21	873	do	48 01	47 48	Growler.
21	874	do	47 58 to 47 38	47 48 to 48 50	20 large bergs north and south of line.
21	875	Thuban	47 23 to 47 05	45 22 to 46 17	5 bergs and several growlers.
21	876	St. Amos Fafalios	45 04	45 46	2 bergs.
22	877	Scythia	47 33	49 49	Berg.
22	878	do	48 08	48 38	Numerous bergs and growlers each side of track.
22	879	do	48 06	48 45	Large berg.
22	880	do	48 05	48 45	2 long, low bergs.
21	881	Frederick VIII	46 50	40 31	Large berg.
22	882	Beaverford	47 29	48 23	Berg.
22	883	do	47 40	47 38	Growler.
22	884	Scythia	48 16	48 14	Berg.
22	885	Cape Race Station	48 10 to 47 38	46 45 to 48 50	36 bergs and many growlers both sides of track.
22	886	do	47 36 to 48 35	50 26 to 48 06	17 bergs and many growlers both sides of track.
22	887	do	47 27	43 51	Berg.
22	888	do	47 08	44 41	3 growlers.
22	889	do	47 11	45 00	Berg.
22	890	do	47 09	45 11	Large berg and growlers.
22	891	do	47 05	45 30	2 bergs and 2 growlers.
22	892	do	47 04	45 44	Berg.
22	893	do	46 55	45 53	Do.
22	894	do	46 55	46 00	2 bergs.
23	895	Caledonia	48 34	48 02	Growler.
23	896	do	48 25	48 14	Berg and 5 growlers.
23	897	Koeln	49 00	48 16	Growler.
23	898	do	48 57	48 18	Do.
23	899	Cape Race Station	48 20 to 47 45	48 43 to 50 10	Numerous bergs and growlers on track.
23	900	Hada County	48 06	47 55	Growlers.
23	901	do	48 04	48 00	Small berg.
23	902	do	47 54 to 47 40	48 40 to 49 35	8 bergs and many growlers.
23	903	Koeln	48 07	48 50	Field ice with uncountable growlers and large and small bergs.
23	904	Regina	48 43	48 19	Growlers.
23	905	do	48 36	48 33	Large berg also field ice and growlers on both side of track extending towards south-southwest.
23	906	Caledonia	48 23	48 29	Large berg.
23	907	do	48 21 to 48 18	48 23 to 49 03	Field ice extending north and south to horizon with growlers, small bergs, and two large bergs.
23	908	do	48 14	49 17	Large berg.
23	909	do	48 14	49 13	Very large berg.
23	910	do	48 09	49 14	Small berg.
23	911	do	48 08	49 18	Large berg.
23	912	Koeln	47 58	49 13	Do.
23	913	Heronspool	45 46	47 26	Do.
23	914	do	45 46	47 22	Large berg and growlers.
23	915	do	45 59	47 11	Very large berg.
23	916	Caledonia	48 20	49 40	Large berg.
23	917	do	48 00	49 40	Do.
23	918	do	47 57	49 42	Very large berg.
23	919	do	47 54	49 59	Large berg.
23	920	Cape Race Station	48 40	49 59	Small berg.
23	921	do	48 37	50 10	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 23	922	Cape Race Station	48 36	50 13	Small berg.
23	923	do	48 27	50 20	Do.
23	924	do	48 28	50 23	Do.
23	925	do	48 23	50 40	Do.
23	926	do	48 33 to 48 32	48 42 to 48 48	Field of broken hummocky ice.
23	927	do	48 32 to 47 57	48 48 to 50 06	Scattered bergs and growlers north and south of track.
23	928	do	48 02	49 14	Very large berg.
23	929	do	48 13 to 47 10	47 24 to 49 00	Many bergs and growlers both sides of track.
24	930	Ascania	47 59	46 40	Small berg.
24	931	Athenia	48 37	48 12	3 growlers and several pieces of ice.
24	932	do	48 32	48 28	Growler.
24	933	Heronspool	46 12 to 46 34	46 08 to 45 13	13 bergs.
24	934	Empress of Australia	47 45 to 48 00	47 20 to 46 30	7 bergs and some pieces.
23	935	Cape Race Station	48 20 to 47 45	48 43 to 50 10	Numerous bergs and growlers on "F" track.
23	936	do	48 21	48 23	Large berg.
23	937	do	48 02	49 14	Do.
23	938	do	48 13 to 47 10	47 24 to 49 00	Many bergs and growlers both sides of track.
24	939	do	45 04	48 38	Large berg.
24	940	do	47 58	50 06	Berg.
24	941	Ice patrol	42 53	51 13	Growler.
24	942	Heronspool	46 41	44 23	2 bergs.
24	943	Kentucky	48 02	50 36	Berg.
23	944	do	47 21	51 40	3 bergs.
24	945	do	48 16	50 10	Berg.
24	946	do	48 20 to 48 44	50 03 to 49 28	Field ice with growlers and 1 berg.
24	947	Ascania	47 57 to 47 35	46 51 to 48 59	35 scattered bergs and growlers north and south of track.
24	948	Selvistan	44 20	47 14	Large berg and 4 growlers.
24	949	Athenia	48 37	48 12	3 growlers, numerous pieces.
24	950	do	48 32	48 28	1 growler and pieces.
24	951	do	48 22	48 48	Berg.
24	952	do	48 18	48 57	Berg and several growlers.
24	953	do	48 16	49 07	Berg.
24	954	do	48 12	49 07	Do.
24	955	do	48 18	49 19	Do.
24	956	do	48 07	49 24	4 bergs.
24	957	do	47 55	49 49	Berg.
24	958	do	47 25	51 33	Do.
24	959	Cape Race Station	47 38 to 48 00	48 14 to 46 30	13 bergs, 4 growlers.
25	960	Vallemare	45 27 to 45 54	47 18 to 48 07	9 bergs and many growlers.
25	961	Edouard Jeramec	45 08	46 14	Large berg.
25	962	do	45 11	46 58	Do.
25	963	do	45 11	46 59	Do.
25	964	do	45 05	47 09	Small berg.
25	965	do	44 59	47 16	Very large berg and growler.
25	966	Cape Race Station	47 30	43 42	Berg.
25	967	do	47 14	44 49	Do.
25	968	do	47 26	44 52	Do.
25	969	do	47 07	44 35	Do.
25	970	do	47 07	45 17	Do.
25	971	do	46 47	46 53	17 large bergs, 26 large growlers, and numerous pieces along track and north and south to horizon.
25	972	do	46 46 to 46 50	47 00 to 47 05	5 large bergs.
25	973	do	46 42	47 20	2 large bergs.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 25	974	Cape Race Station	46 56	47 10	2 large bergs.
26	975	Odensholm	47 30	51 38	3 bergs.
26	976	Cape Race Station	48 10	49 20	2 large bergs.
26	977	do	48 30	49 50	Do.
27	978	Homeric	40 28	50 01	Buoy about 10 feet high painted red with superstructure black, square cage on top.
28	979	Vlieland	48 25	45 50	Berg and growlers.
27	980	Cape Race Station	48 35 to 48 10	49 48 to 50 30	Several large bergs and numerous growlers extending north and south as far as could be seen.
28	981	Antonia	47 16	51 18	Small berg.
28	982	do	47 55	49 58	Large berg.
28	983	do	48 07	49 34	Ice island.
28	984	do	48 07	49 15	Small berg.
28	985	do	48 09	49 14	Large berg.
28	986	do	48 01	48 52	Large berg and growler.
28	987	do	48 16	48 22	Small berg.
28	988	Metagama	48 13	48 50	Large berg.
28	989	do	48 11	48 50	Very large berg.
28	990	do	48 15	48 42	Berg.
28	991	do	48 14	48 39	Do.
28	992	Cape Race Station	48 07	48 52	Small berg.
28	993	do	48 16	48 22	Do.
28	994	Beaverhill	47 38	48 17	Large berg.
28	995	do	47 41	48 17	Do.
28	996	Regnhildholm	43 30	51 30	Small berg.
28	997	Ausonia	48 09	45 49	Berg.
28	998	Montclare	48 22	46 07	Small berg.
28	999	do	48 28	46 20	Large berg.
28	1000	do	48 36	46 23	Growler.
28	1001	do	48 32	46 35	Berg.
28	1002	do	48 27	46 36	2 bergs and small pieces.
28	1003	do	48 33	45 53	Berg.
28	1004	do	48 40	45 55	Growler.
28	1005	do	48 25	46 47	Small berg.
28	1006	do	48 25	46 48	Large and small berg.
28	1007	Beaverhill	47 43 to 47 58	47 30 to 46 30	Numerous bergs and growlers to north and south.
28	1008	do	48 02	45 59	Berg.
28	1009	do	48 05	45 47	Growler.
28	1010	Cape Race Station	48 56	44 46	Spar floating vertically apparently attached to submerged wreckage.
28	1011	Montclare	48 07	48 02	Berg and numerous small pieces.
28	1012	do	48 02	48 17	Berg.
28	1013	do	47 58	48 17	Do.
28	1014	do	47 57	48 31	Do.
28	1015	do	47 53	48 30	2 bergs.
29	1016	Saguache	46 20 to 46 14	44 50 to 44 41	1 large and 2 small bergs and several growlers.
29	1017	Tiger	49 06 to 48 28	49 40 to 50 45	4 large, 10 small growlers, 1 large, 2 small bergs.
28	1018	Cape Race Station	49 00	47 09	Berg.
28	1019	do	48 48	47 25	Do.
28	1020	do	48 49	47 39	Do.
28	1021	do	48 39	47 57	Do.
28	1022	do	48 33	48 28	Do.
28	1023	do	47 57	49 48	Do.
29	1024	California	48 13	49 17	Large berg.
29	1025	do	47 57	48 53	Large berg and several growlers.
29	1026	Nova Scotia	48 20 to 48 52	50 50 to 49 24	100 bergs and unnumerable growlers.
29	1027	Dalcairn	45 50	45 43	Large berg and growler.
29	1028	California	48 13 to 48 21	49 17 to 47 53	9 large, 16 medium, and 9 small bergs, also many growlers north and south of track.
29	1029	do	48 21 to 48 35	47 53 to 47 15	5 bergs north and south of track.
29	1030	Cape Race Station	47 15	44 30	1 large and 1 small berg.
29	1031	do	47 22	45 10	2 small bergs.
29	1032	do	47 00	45 55	2 large bergs, several growlers.
29	1033	do	46 55	46 30	2 large and 1 small bergs.
30	1034	Laurentic	48 26	49 00	Small berg.
30	1035	do	48 18	48 59	Growler.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 30	1036	California	48 11	47 29	3 bergs.
30	1037	do	48 37	47 31	Berg.
30	1038	do	48 46	47 08	2 bergs.
30	1039	do	48 43	46 45	Very large berg.
30	1040	do	48 58	46 31	Berg and many growlers.
30	1041	Andania	48 20	48 57	Growler, same as 1035.
30	1042	Cameronia	48 21 to 48 02	48 49 to 49 09	21 bergs and a number of growlers.
30	1043	Andania	48 35	48 59	Growler.
30	1044	do	48 22	49 16	Do.
30	1045	do	48 19	49 16	Do.
30	1046	do	48 20	49 17	Large berg.
30	1047	do	48 21	49 20	Growlers.
30	1048	do	48 22	49 21	Do.
30	1049	do	48 19	49 20	Berg.
30	1050	do	48 20	49 36	Large berg.
30	1051	do	48 17	49 35	Do.
30	1052	do	48 18	49 43	Do.
30	1053	do	48 12	49 39	Do.
30	1054	do	48 14	49 43	Do.
30	1055	do	48 06	48 36	Do.
30	1056	do	48 17	49 44	Do.
30	1057	do	48 15	49 46	Do.
30	1058	do	48 09	49 45	Do.
30	1059	do	48 14	49 56	Do.
30	1060	Laurentic	48 26 to 48 09	49 00 to 49 33	7 bergs and numerous growlers.
30	1061	do	48 05	49 07	Large berg.
30	1062	do	47 31	51 20	Do.
30	1063	do	47 13	51 44	Do.
30	1064	Arabic	48 30 to 48 20	46 04 to 46 50	5 bergs and several growlers.
30	1065	Minnedosa	48 31	46 29	2 bergs and several growlers.
30	1066	do	48 24	46 50	Small berg.
30	1067	Andania	47 30	51 19	Large berg.
30	1068	do	47 27	51 25	Berg.
30	1069	Cape Race Station	46 28 to 46 13	47 05 to 47 53	10 large, 3 small bergs.
30	1070	Andania	47 16	51 37	Berg.
30	1071	Arabic	48 06 to 47 48	47 46 to 48 48	10 bergs and 2 growlers.
30	1072	Hardenberg	45 05 to 45 03	49 13 to 48 25	5 bergs.
30	1073	Sonda	47 00	46 34	Small berg.
31	1074	Minnedosa	48 09	47 44	Growler.
31	1075	do	48 04	47 56	Small berg and piece.
31	1076	do	48 00	48 08	Growler.
31	1077	do	48 00	48 19	4 growlers.
31	1078	do	47 58	48 27	Growler.
31	1079	do	47 54	48 27	2 small bergs.
31	1080	do	47 55	48 31	Growler and 2 pieces.
31	1081	do	47 52 to 47 49	48 42 to 48 52	2 large and 3 medium bergs and 1 growler.
31	1082	do	47 41	49 20	Berg.
31	1083	Arabic	47 46	48 50	Large low berg.
31	1084	do	47 43	49 00	Berg.
31	1085	do	47 45	49 04	Berg and growler.
31	1086	do	47 40	49 16	Growler.
31	1087	Villaperosa	45 02 to 45 34	47 47 to 46 50	13 large bergs.
31	1088	do	45 34 to 45 40	46 50 to 46 35	3 small bergs.
31	1089	Minnedosa	47 04	51 48	Berg.
31	1090	Cape Race Station	48 31	46 29	2 bergs, 4 growlers, and several pieces.
31	1091	do	48 24	46 50	Small berg.
31	1092	Ice patrol	43 04	48 57	Large berg.
31	1093	do	43 20	48 55	Do.
31	1094	do	43 17	49 03	Do.
31	1095	do	42 53	49 07	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
May 31	1096	Ice patrol	43 05	49 29	Large low berg.
31	1097	Trevaljan	46 03 to 46 17	47 50 to 46 25	19 bergs and several growlers.
31	1098	do	46 12	46 47	Berg and many growlers.
31	1099	do	46 12	46 23	2 bergs.
31	1100	do	46 18	45 08	Berg.
31	1101	America	40 34	55 47	Large tree covered with marine growth.
31	1102	Carmia	48 25	49 30	Berg.
31	1103	do	47 47	50 55	Do.
June 1	1104	America	40 55	50 37	Tall white cage lattice top buoy surmounted by black square top; lettered A, B, E, L, on side; lower part of buoy covered with marine growth.
1	1105	Fluorspar	41 22	48 23	Log about 20 feet long and 2 feet diameter.
1	1106	Beaverbrae	48 17	46 30	Large berg and several growlers.
1	1107	Ice patrol	42 55	49 26	Large berg, same as 1096.
1	1108	do	42 52	49 11	Large berg, same as 1092.
1	1109	do	42 48	49 17	Large berg, same as 1095.
1	1110	Montcalm	47 12	49 20	Low-lying berg.
1	1111	do	47 14	49 15	Small-piece ice.
1	1112	do	47 18	49 00	Growler.
1	1113	do	47 20	48 52	Berg.
1	1114	do	47 21	48 42	Growler.
1	1115	do	47 22	48 40	Small-piece ice.
1	1116	do	47 23	48 28	Berg.
1	1117	do	47 22 to 47 40	48 39 to 47 16	4 bergs, 2 growlers, and numerous pieces.
1	1118	do	47 26	48 30	Extremely low-lying berg and low-lying ice.
1	1119	Ice patrol	43 06	49 08	Large berg, same as 1094.
1	1120	Beaverbrae	47 46 to 47 38	48 16 to 48 46	9 bergs and numerous pieces, and soft pack.
1	1121	Ice patrol	42 40	49 25	Large berg.
1	1122	American Shipper	40 43	56 48	Spar projecting 5 feet apparently attached to submerged wreckage.
1	1123	Cape Race Station	47 15 to 46 54	51 15 to 51 40	2 large and 2 small bergs and several growlers.
2	1124	Beaverbrae	47 30	48 57	Low flat berg and small pieces.
2	1125	do	47 28	49 00	3 growlers.
2	1126	do	47 25	49 17	Berg.
2	1127	do	47 28	49 20	Do.
2	1128	Esonia	47 43	51 05	Small growlers.
2	1129	do	47 46	50 59	Do.
2	1130	Valfiorota	43 46	48 10	Large berg.
2	1131	do	43 42	48 12	Berg.
2	1132	do	43 41	48 17	Berg, 2 small bergs, and several pieces.
2	1133	Korsholm	47 55 to 47 45	50 20 to 50 50	4 bergs and several growlers.
2	1134	Concordia	46 45	52 13	Small berg.
2	1135	do	46 47	52 07	Do.
2	1136	do	46 52	52 03	Do.
2	1137	do	46 55	51 35	Do.
2	1138	Korsholm	47 14	51 45	Berg.
2	1139	Beaverbrae	47 01 to 47 06	50 10 to 49 52	5 bergs.
2	1140	Cape Race Station	46 45	52 15	Berg, same as 1134.
2	1141	do	47 01 to 47 06	50 10 to 49 52	5 bergs, same as 1139.
3	1142	do	46 43	52 27	Berg.
3	1143	do	46 41	52 33	Growler.
3	1144	do	46 44	52 38	Berg.
3	1145	Bird City	49 34	48 08	Large berg.
3	1146	Athenia	47 24	51 00	Growler.
3	1147	Concordia	47 20	51 17	Berg.
3	1148	do	47 25	50 55	Small berg.
3	1149	do	47 42	50 02	Large berg.
3	1150	do	47 39	50 15	Berg.
3	1151	Ascania	47 20	50 00	Large berg.
3	1152	do	47 16	49 50	Berg and growlers.
3	1153	do	47 27	49 50	Large berg.
3	1154	Ranja	40 37	56 05	Spar floating upright apparently attached to submerged wreckage.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 3	1155	Pennsylvania	40 15	47 30	Spar 10 feet long 3 feet diameter dangerous to navigation.
3	1156	Teucer	40 28	43 37	Red iron cylinder about 40 feet long and 6 feet high.
3	1157	Bird City	48 15	50 15	1 large and 1 small berg.
4	1158	Athenia	47 24	51 00	Growler, same as 1146.
4	1159	do	47 33	50 41	2 bergs.
4	1160	do	47 41	50 29	Growler.
4	1161	do	47 36	50 29	Berg.
4	1162	do	47 37	50 14	Do.
4	1163	do	47 42	50 14	2 growlers.
4	1164	do	47 44	50 08	1 berg.
4	1165	do	47 43	50 05	Berg.
4	1166	do	47 47	49 53	3 bergs.
4	1167	do	47 52	49 48	Berg.
4	1168	Parklaan	42 54	51 10	Large berg.
4	1169	Bird City	47 50	51 06	2 large bergs, 1 growler.
4	1170	Ascania	47 40	48 37	Large berg.
4	1171	do	47 38	48 12	24 bergs and growlers scattered north and south of track.
4	1172	Etna	44 43	47 31	Berg and growler.
4	1173	do	44 40	47 53	Do.
4	1174	do	44 30	48 44	Berg and growler.
3	1175	Blair Gourie	42 47	49 00	Berg.
3	1176	Cape Race Station	46 08	48 00	Do.
3	1177	do	46 09	47 55	Large low-lying berg.
4	1178	do	47 40	50 18	Berg and growlers.
4	1179	do	47 38	50 24	Do.
4	1180	do	47 32	50 32	Do.
4	1181	do	47 25	50 30	Do.
4	1182	Caledonia	46 42	51 49	Small berg and growler.
4	1183	do	47 04	51 33	Berg and numerous small pieces.
4	1184	Ice patrol	42 50	49 04	Large berg.
4	1185	do	42 43	49 00	Do.
4	1186	do	42 33	49 48	Large berg and growlers.
4	1187	United States	42 26	49 45	Large berg, same as 1186.
4	1188	do	42 28	50 02	Large berg.
4	1189	Caledonia	47 14	51 20	Do.
4	1190	do	47 18	50 57	Growler.
4	1191	do	47 35	50 43	2 bergs.
4	1192	do	47 28	50 40	Very large berg.
4	1193	do	47 37	50 29	Do.
4	1194	do	47 45	50 20	2 large bergs.
4	1195	do	47 40	50 08	Berg and growlers.
4	1196	Naples Maru	43 05	49 10	3 large bergs.
5	1197	Regina	47 17	50 44	Several bergs.
5	1198	Koeln	47 48	50 48	Several small bergs.
5	1199	Caledonia	47 47	49 50	Large berg.
5	1200	do	47 44	49 42	Do.
5	1201	Koeln	47 44	50 41	Several bergs.
5	1202	Naples Maru	43 10	52 08	Numerous growlers.
5	1203	do	43 07	52 17	Large berg and growlers.
5	1204	Cape Race Station	47 46	49 42	Two large bergs.
5	1205	do	47 17 to 47 44	50 44 to 49 40	A number of bergs on each side of track.
5	1206	do	48 16	49 31	Do.
5	1207	do	47 54	50 17	Do.
5	1208	do	47 50	50 25	Do.
5	1209	do	47 49	50 27	Do.
5	1210	do	47 47	50 32	Do.
5	1211	do	47 44	50 39	Do.
5	1212	do	47 37	51 50	Do.
5	1213	do	47 39	51 01	Do.
5	1214	do	47 23	51 09	Do.
5	1215	do	47 18	51 36	Do.
5	1216	do	47 04	51 58	Do.
5	1217	do	47 34	45 44	Growlers.
5	1218	do	47 27	45 48	Large berg.
5	1219	do	47 18	46 35	Do.
5	1220	Koeln	48 32	49 09	2 small bergs.
5	1221	Ice patrol	42 29	50 19	Berg and growlers, same as 1188.
5	1222	do	42 36	50 07	Berg.
5	1223	do	42 42	50 23	Do.
5	1224	do	42 26	49 53	Large berg and growlers, same as 1186.
5	1225	Regina	48 19	48 03	Large berg.
5	1226	do	48 40	47 42	Small berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position		Nature of ice or obstruction
			Latitude north	Longitude west	
			° ′	° ′	
June 5	1227	Doric	48 24 to 48 02	48 45 to 49 40	Several growlers.
5	1228	do	48 14	49 10	Berg.
5	1229	do	48 05	49 32	Low-lying berg.
6	1230	Melita	47 49	49 43	Berg.
6	1231	do	47 46	49 51	Growlers.
6	1232	do	47 34	50 06	Berg.
6	1233	do	47 29	50 12	Do.
6	1234	do	47 40	50 20	Do.
6	1235	Empress of Australia	47 30	49 25	18 bergs, 5 growlers, numerous pieces north and south of track.
6	1236	Montrose	47 09	50 42	Growler.
6	1237	do	46 55	51 32	Do.
6	1238	do	46 51	51 49	2 bergs.
6	1239	do	46 53	52 18	Berg.
6	1240	do	46 44	52 27	Do.
6	1241	Melita	48 07	49 04	Do.
6	1242	do	48 07	49 00	Growlers.
6	1243	Montrose	47 28 to 47 11	49 07 to 50 37	7 bergs, 1 growler on or near track.
6	1244	Doric	47 25	51 07	Very large low berg.
6	1245	Polonia	45 57	43 25	Berg.
6	1246	do	44 55	46 57	Do.
6	1247	Koranton	42 59	51 16	Do.
6	1248	do	43 00	51 00	Hogshead painted black with white band carrying mast surmounted with lantern.
6	1249	Letitia	49 08	47 10	Berg.
6	1250	Empress of Australia	47 07	50 38	7 bergs, 4 growlers, and numerous pieces, one low-lying dangerous berg.
6	1251	Cairnross	48 00	50 22	Berg.
6	1252	do	48 02	50 33	Do.
6	1253	do	47 51	50 51	Berg and growlers.
6	1254	Cape Race Station	47 49 to 47 19	50 55 to 51 50	16 bergs and several growlers on both sides of track.
6	1255	do	48 26 to 47 25	48 44 to 51 07	14 bergs and many growlers on both sides of track.
6	1256	do	46 39	52 48	Large berg.
6	1257	Melita	47 32	50 26	Berg.
6	1258	do	47 29	50 24	Do.
6	1259	do	47 16	51 02	Do.
6	1260	Alaunia	47 39	49 14	Growlers.
6	1261	do	47 42	49 26	Berg.
6	1262	do	47 47	49 34	Bergs and growlers.
6	1263	do	47 29	49 24	Do.
6	1264	do	47 35	49 40	Do.
6	1265	do	47 29	49 39	Do.
6	1266	do	47 32	49 45	Do.
6	1267	Polonia	44 53	47 35	Berg.
6	1268	do	44 48	47 46	3 growlers.
6	1269	Mincio	42 58	52 30	Large berg.
6	1270	Alaunia	47 02 to 47 29	50 56 to 49 55	20 bergs and many growlers north and south of track.
6	1271	Einarjarl	40 05	44 16	Cylindrical iron tank 18 feet long 3½ feet diameter apparently long time in water, no visible marks, no color.
6	1272	Ice patrol	42 26	49 43	Berg and growlers, same as 1186.
6	1273	Bergensfjord	46 04	44 00	Berg.
6	1274	Letitia	48 24	48 46	Large berg.
6	1275	do	48 14	48 59	Do.
6	1276	Melita	46 57	51 46	Berg.
6	1277	do	46 59	52 08	Do.
6	1278	do	46 48	52 08	Do.
6	1279	do	46 44	52 15	Do.
6	1280	do	47 00	52 32	Do.
6	1281	Letitia	48 14 to 47 56	48 59 to 50 30	12 bergs with growlers and small pieces; westernmost berg 250 feet high.
6	1282	President Wilson	40 29	48 17	Large, round smooth spar 25 feet long 1 foot diameter.
6	1283	St. Amos Fafalios	42 42	51 15	Berg.
7	1284	Letitia	47 40 to 47 30	50 40 to 50 45	9 bergs, several growlers, and several pieces.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 7	1285	Scythia	48 35	46 52	Small berg.
7	1286	Eupatoria	42 11	43 26	Piece of wreck 25 meters long, 1 to 2 meters high.
7	1287	St. Amos Fafalios	41 38	48 56	Very large berg.
7	1288	Beaverbrae	47 03	51 05	3 growlers.
6	1289	Cape Race Station	46 35 to 48 00	52 15 to 48 40	40 bergs and many growlers north and south of track.
7	1290	Oxelosund	44 54	47 02	Berg.
7	1291	do	44 45	47 40	3 bergs.
7	1292	Megantic	47 12	51 06	Low-lying berg.
7	1293	do	47 04	51 11	Large berg.
7	1294	Bergensfjord	42 24	49 40	Large berg same as 1186.
7	1295	Megantic	46 58	51 34	1 large berg, 1 low berg, and 4 growlers.
7	1296	Scythia	47 33	47 31	Growlers.
7	1297	do	47 24	51 16	Small bergs.
7	1298	do	47 21	50 22	Do.
7	1299	do	47 26	50 32	Large berg.
7	1300	do	47 37 to 47 24	49 43 to 50 16	Several small pieces.
7	1301	Oxelosund	44 35	48 47	Several bergs.
7	1302	Bergensfjord	42 29	50 27	Berg.
7	1303	Pipiriki	46 27	40 55	Small berg.
7	1304	Cynthia	46 56	50 39	Small flat berg.
7	1305	do	47 02	51 14	Large berg.
7	1306	do	46 49	51 30	Small berg.
7	1307	do	46 37	51 58	Flat berg.
7	1308	do	46 40	52 22	Large berg.
8	1309	Scythia	46 40	52 10	Small berg.
8	1310	Hatteras	46 03	40 55	Berg 200 feet long, 50 feet high, same as 1298.
7	1311	Cape Race Station	48 57	50 05	Berg.
8	1312	Lord Kelvin	45 42	48 15	2 bergs.
8	1313	do	45 52	48 09	Berg.
9	1314	Montclare	46 54	51 36	Small flat berg.
8	1315	Cape Race Station	46 40	52 36	Berg drifting southwest.
9	1316	do	47 28	50 12	Berg.
9	1317	do	47 36	51 59	4 bergs.
9	1318	do	48 03	51 00	4 bergs and 1 large berg.
9	1319	do	47 54	50 33	Large berg.
9	1320	do	48 00	50 35	Do.
9	1321	do	48 08	50 44	Do.
9	1322	Montclare	47 09	50 38	Berg.
9	1323	do	47 18	50 11	Do.
9	1324	do	47 22	50 02	Growler.
9	1325	do	47 25	50 03	Berg.
9	1326	do	47 17	49 59	Do.
9	1327	do	47 16	49 56	Do.
9	1328	do	47 18	49 53	Do.
9	1329	do	46 54 to 47 37	51 33 to 48 53	28 bergs and numerous growlers north and south of track.
9	1330	Tiger	47 10 to 48 04	51 48 to 50 36	50 bergs and numerous growlers along track.
9	1331	Tyrifjord	42 52	48 41	8 bergs.
9	1332	do	42 46	48 52	Berg.
9	1333	do	42 30	49 43	Large berg, same as 1186.
9	1334	Cape Race Station	46 35	45 29	Large berg and growler.
9	1335	do	46 12	45 43	Large berg.
9	1336	do	46 18	46 03	Do.
9	1337	do	46 16	46 11	Do.
9	1338	do	48 18	50 23	Berg.
9	1339	do	48 24	50 30	Large berg.
9	1340	do	48 24 to 48 22	50 20 to 49 46	Growlers.
9	1341	do	48 28	49 50	Large berg.
9	1342	do	48 40	49 00	Do.
9	1343	do	48 22	49 01	4 small bergs and 2 small growlers.
9	1344	Montclare	48 08	47 14	Large berg.
10	1345	Ice patrol	42 32	49 48	Berg and growlers, same as 1186.
10	1346	Highcliffe	45 45	47 28	Large berg.
10	1347	do	45 39	45 25	Growlers and several pieces.
10	1348	Ice patrol	42 43	50 05	Berg.
9	1349	Cape Race Station	46 39	52 46	Large flat low berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position		Nature of ice or obstruction
			Latitude north	Longitude west	
			° ′	° ′	
June 10	1350	Cape Race Station	46 37 to 48 16	52 33 to 48 39	8 bergs.
10	1351	do	48 24	49 00	Small berg.
10	1352	do	48 17	49 13	Do.
10	1353	do	47 47	50 12	Berg.
10	1354	do	47 45	50 26	Four bergs.
10	1355	do	47 42	50 32	Berg and 2 growlers.
10	1356	do	47 39	50 38	Berg and several growlers.
10	1357	do	47 18	51 25	2 bergs.
10	1358	do	47 03	47 51	3 small bergs and 5 growlers.
10	1359	Ice patrol	43 02	50 22	2 bergs.
10	1360	do	43 04	50 00	Berg.
11	1361	Nieu Amsterdam	48 15	46 12	Growler.
11	1362	do	48 03	46 45	Do.
11	1363	do	47 47	47 10	Do.
11	1364	Kungsholm	42 19	49 40	Small berg.
11	1365	Nieu Amsterdam	47 24	43 51	Do.
11	1366	do	47 20	49 11	Growler.
11	1367	do	47 07	49 46	Berg.
11	1368	Minnedosa	47 37	51 02	Do.
11	1369	Andania	46 37	52 33	Large berg.
11	1370	do	46 49	52 15	Growler.
11	1371	do	46 49	52 11	3 growlers.
11	1372	do	46 57	52 04	Berg.
11	1373	do	47 14	51 03	Do.
11	1374	do	47 33	50 33	3 bergs.
11	1375	do	47 30	50 09	Berg.
11	1376	do	47 35	50 10	2 bergs.
11	1377	do	47 40	49 50	2 bergs and growlers.
11	1378	do	47 57	49 34	Berg.
11	1379	do	48 00	49 10	Growler.
11	1380	do	48 18	48 30	2 growlers.
11	1381	do	48 13	48 28	Do.
11	1382	do	48 33	48 25	Large berg.
11	1383	Laurentic	46 38	52 29	Large flat berg.
11	1384	do	46 54	51 26	Small berg.
11	1385	Ice patrol	42 27	49 52	Berg, same as 1186.
11	1386	do	42 42	50 03	Large berg.
11	1387	do	42 37	50 22	Berg, same as 1343.
11	1388	do	43 05 to 42 50	50 40 to 49 45	7 bergs.
11	1389	do	42 39	49 53	Several growlers.
11	1390	Minnedosa	47 43 to 47 52	50 58 to 50 41	6 bergs and 4 growlers.
11	1391	do	48 01	50 41	11 large bergs.
11	1392	do	47 57	50 35	Growler.
11	1393	do	47 51	50 18	Berg.
11	1394	do	47 55	50 17	Do.
11	1395	do	47 58	50 20	Growler.
11	1396	do	48 02	50 21	Large berg.
11	1397	do	48 16	50 15	Do.
11	1398	do	48 06	50 15	Do
11	1399	do	48 11	49 53	Do.
11	1400	Laurentic	46 38	52 29	Do.
11	1401	do	46 54	51 26	Small berg.
11	1402	do	48 19	48 27	Growlers.
11	1403	do	48 14	48 17	Growler and small berg.
11	1404	Cape Race Station	46 49	52 25	Growlers.
11	1405	Nieu Amsterdam	46 54	51 12	Growler.
11	1406	do	46 39	52 22	Large flat berg.
11	1407	C. F. Liljevalch	47 40	52 31	Berg.
11	1408	do	47 53	52 32	Do.
11	1409	do	47 51	52 31	Growler.
11	1410	Ice patrol	42 48	49 24	Large berg.
11	1411	do	42 42	49 40	Growler.
11	1412	do	42 48	48 51	Berg.
11	1413	C. F. Liljevalch	48 10	52 35	Small berg.
11	1414	do	48 01	52 47	2 bergs.
11	1415	do	48 24	52 40	Small berg.
11	1416	do	48 20	52 35	Large berg.
11	1417	do	48 10	52 50	Several bergs and growlers along shore.
11	1418	Dalblair	39 18	50 29	Heavy spar floating vertically, projecting 6 feet.
11	1419	West Kyska	42 11	43 26	Floating oil drum on end, partly submerged.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 12	1420	Villedys	46 45	47 10	Large and 3 small bergs.
12	1421	do	46 50	47 20	Large berg.
12	1422	do	46 44	47 20	Do.
12	1423	Transylvania	48 00	49 49	Growler.
12	1424	do	47 54	50 01	Several growlers.
12	1425	Gripsholm	45 43	42 20	Partly submerged wreckage.
12	1426	Transylvania	47 33	50 45	Berg.
12	1427	do	47 14	51 59	3 small bergs.
12	1428	Montroyal	48 07	47 32	Growler.
12	1429	do	47 55	48 04	Berg.
12	1430	Cape Race Station	47 58 to 48 03	50 53 to 50 44	11 bergs.
12	1431	do	47 57 to 48 02	50 35 to 50 21	3 large bergs and 2 growlers.
12	1432	do	48 27	48 58	Small berg.
12	1433	do	47 45 to 48 10	52 45 to 51 01	40 bergs.
12	1434	Mount Royal	47 43	48 41	Berg.
12	1435	do	47 35	49 17	Large berg and 2 growlers.
12	1436	Transylvania	46 59	52 00	Small berg and growler.
12	1437	do	46 59	52 14	Do.
12	1438	do	46 45	52 40	Large berg and 7 growlers.
12	1439	Mount Royal	47 28	49 33	Growler.
12	1440	do	47 31	49 34	Large berg.
12	1441	do	47 22	50 16	Berg and several growlers.
12	1442	Montroyal	47 27	48 38	Berg.
12	1443	do	47 31	49 41	2 bergs.
13	1444	Cameronia	48 05	49 45	Several pieces of ice.
13	1445	Crefeld	49 03 to 48 33	50 48 to 51 16	Great number of large and small bergs; many bergs still ahead.
13	1446	Zonnewyk	42 52	51 32	Small berg.
13	1447	do	43 01	51 56	Berg.
13	1448	do	43 06	51 56	Large berg.
13	1449	do	43 15	52 12	2 bergs.
13	1450	Gripsholm	42 31	49 33	Berg.
12	1451	Cape Race Station	48 40	45 30	Long, low dangerous berg 4 feet high.
13	1452	Urania	47 43	48 12	Low berg.
13	1453	do	47 50	48 12	Growler.
13	1454	do	47 48	48 08	Do.
13	1455	Pennland	48 32	45 28	Low-lying berg.
13	1456	Ice patrol	42 57	49 16	Berg and growlers.
13	1457	do	42 54	49 16	Small berg.
13	1458	Crefeld	47 38	51 48	3 large bergs.
13	1459	do	48 30 to 47 38	51 16 to 51 48	Many bergs.
13	1460	Ice patrol	42 55	49 40	Large berg and growlers.
13	1461	do	42 53	49 50	Do.
13	1462	do	42 58	49 41	Berg.
13	1463	Aurania	47 52	48 42	Berg and growler.
13	1464	do	47 44	48 58	Growler.
13	1465	do	47 43	49 00	Small growler.
13	1466	do	47 38	49 19	Large berg.
13	1467	Metagama	48 26	48 17	Low berg.
13	1468	Pennland	48 08	47 17	Growler and several pieces.
13	1469	Montroyal	47 07	51 04	Large berg.
13	1470	Beaverbrae	47 14	49 12	Berg.
13	1471	do	47 18	48 54	Do.
13	1472	do	47 22	48 42	Do.
13	1473	do	47 24	48 42	Do.
13	1474	do	47 27	48 42	Do.
13	1475	do	47 26	48 32	Do.
13	1476	do	47 20	48 30	Do.
13	1477	do	47 21	48 29	Do.
13	1478	Metagama	48 06	49 04	Large berg.
13	1479	do	48 02	49 11	Do.
13	1480	do	47 55	49 35	Small berg.
13	1481	Empress of Australia	46 46	52 27	Large low berg.
13	1482	Frode	47 38	44 22	Several heavy growlers.
13	1483	Deerlodge	40 53	47 10	White cage top buoy.
13	1484	Cape Race Station	47 18	48 54	Berg.
13	1485	do	48 36	49 43	Do.
13	1486	do	48 10	50 18	Large berg.
13	1487	do	48 05	50 30	Several bergs in vicinity.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
June 13	1488	Cape Race Station	47	53	50	45	Small berg.
13	1489	do	47	30	49	39	Berg.
13	1490	do	47	29	49	44	Do.
13	1491	do	48	45	50	55	Do.
13	1492	do	48	49	50	31	Do.
13	1493	do	48	30	50	21	Do.
13	1494	do	48	39	50	38	Do.
13	1495	Metagama	47	56	49	40	Do.
13	1496	do	47	53	49	42	Do.
13	1497	do	47	44	50	28	Do.
13	1498	do	47	38	50	47	Large low-lying berg.
13	1499	do	47	56	49	40	Berg.
13	1500	Aurania	47	30	49	39	Do.
13	1501	do	47	29	49	44	Do.
13	1502	Antonia	48	45	50	58	Do.
13	1503	do	48	22	51	36	Do.
13	1504	do	48	20	51	45	Do.
13	1505	do	48	13	51	51	Do.
13	1506	do	48	04	51	48	Do.
13	1507	do	48	01	51	58	Do.
13	1508	do	48	38	51	41	Do.
13	1509	do	48	24	51	45	Do.
13	1510	do	48	16	51	40	Do.
13	1511	do	48	10	51	59	Do.
13	1512	do	48	03	51	48	Do.
13	1513	do	48	40	51	21	Do.
13	1514	do	48	29	51	42	Do.
13	1515	do	48	20	51	45	Do.
13	1516	do	48	17	51	58	Do.
13	1517	do	48	09	51	56	Do.
13	1518	do	48	02	51	48	Do.
13	1519	do	47	56	52	11	Do.
13	1520	do	47	54	52	18	Do.
13	1521	Pennland	48	08	47	17	Growler and small berg.
13	1522	do	47	55	48	13	Small berg.
13	1523	do	47	42	48	40	Small flat berg.
13	1524	do	47	36	48	31	Berg.
13	1525	do	47	33	48	43	Do.
14	1526	Metagama	46	56	51	54	Large berg.
14	1527	do	46	55	51	56	Do.
14	1528	do	46	55	51	57	Do.
14	1529	do	46	51	52	13	Large long berg.
13	1530	Cape Race Station	46 46 to 48	46 00	48 50 to 52	50 27	35 bergs and growlers.
14	1531	do	48	38	48	00	Berg.
14	1532	do	48	00	48	12	Do.
14	1533	do	47	54	48	52	Do.
14	1534	do	48	00	49	16	Do.
14	1535	do	47	47	49	31	Do.
14	1536	do	48	26	48	17	Do.
14	1537	do	48	06	49	04	Do.
14	1538	do	48	02	49	11	Do.
14	1539	do	47	55	49	35	Do.
14	1540	do	47	56	49	40	Do.
14	1541	do	47	56	49	42	Do.
14	1542	do	47	53	49	42	Do.
14	1543	do	47	44	50	28	Do.
14	1544	do	47	38	50	47	Do.
14	1545	Frode	46	16	47	50	Large and 2 small bergs.
14	1546	Empress of Australia	47	33	48	36	Berg.
14	1547	do	47	55	46	55	Do.
14	1548	Stagpool	45	00	48	35	2 large and 2 small bergs.
14	1549	Cape Race Station	47	20	49	37	Berg.
14	1550	do	47	47	47	32	Do.
14	1551	do	46	52	51	07	Do.
14	1552	Beaverford	47	58	46	56	Small berg, same as 1547.
14	1553	do	47	49	47	42	Small berg.
14	1554	do	47	36	48	35	Berg.
14	1555	do	47	31	48	53	Small berg.
14	1556	do	47	27	49	10	Do.
14	1557	do	47	25	49	08	Do.
14	1558	do	47	25	49	37	Berg.
14	1559	do	47	15	49	52	Large berg and 1 growler.
14	1560	do	47	11	49	56	Large berg.
14	1561	Toruguero	40	09	51	34	Spar 40 feet long covered with marine growth.
14	1562	do	40	09	51	08	Spar 50 feet long 2 feet diameter covered with marine growth.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 14	1563	Pennland	47 02	52 07	Small berg.
14	1564	do	46 50	52 27	Large berg.
14	1565	Nevisian	37 28	67 26	Schooner Cutty Sark abandoned on fire rudder gone, salt cargo, leaking badly.
14	1566	Mansepool	42 48	50 05	Berg and growler.
14	1567	Cape Race Station	47 27 to 47 50	49 25 to 48 20	18 bergs and numerous growlers.
14	1568	do	47 25 to 47 00	49 25 to 51 13	6 bergs.
14	1569	do	48 10	47 12	Growlers.
14	1570	do	48 07	47 25	Small berg.
14	1571	do	48 00	48 0[illegible]	Berg.
14	1572	do	47 54	48 53	Large berg and growlers.
14	1573	do	47 51	49 04	Berg.
14	1574	do	47 39	48 58	Do.
14	1575	do	47 40	49 06	Do.
14	1576	do	43 45	51 20	Do.
15	1577	Hesperos	43 17	48 10	Do.
15	1578	Melmore Head	48 09	48 39	Large growler.
15	1579	do	47 56 to 47 37	48 50 to 48 47	4 large and 1 small berg and 1 growler.
15	1580	do	47 55	49 09	2 large bergs, 2 large growlers.
15	1581	Toruguero	41 22	45 02	Large rusty iron barrel, shape resembling buoy.
15	1582	City of Fairbury	45 05	47 16	Berg.
15	1583	do	44 55	47 44	Large berg.
15	1584	do	44 47	48 25	Several small bergs and growlers.
15	1585	do	44 41	48 36	Small berg.
15	1586	Valleluce	43 55	48 14	2 large bergs.
15	1587	Ice patrol	42 17	49 23	Berg.
15	1588	Hesperos	43 06	49 04	Do.
15	1589	do	43 06	49 15	Large berg and several growlers.
15	1590	Manchester Hero	48 10	49 03	Berg.
15	1591	Montrose	47 14 to 47 30	49 38 to 48 22	12 bergs and numerous growlers.
15	1592	Tortuguero	41 40	44 16	Large rusty iron barrel resembling a buoy.
15	1593	Manchester Hero	47 50	49 50	2 large bergs and several growlers.
15	1594	Valleluce	43 50 to 44 00	48 12 to 48 35	8 large bergs.
15	1595	Melmore Head	47 34	49 57	2 bergs and 1 growler.
15	1596	Amersham	45 29	49 20	Small berg.
15	1597	do	45 27	47 22	Large berg.
15	1598	do	45 20	45 17	Growler.
15	1599	Ovre	47 36	41 17	Berg.
15	1600	Melmore Head	47 18	50 55	Growler.
15	1601	do	47 11	50 51	Large berg.
15	1602	City of Canberra	48 00	47 18	Berg 100 feet high 600 feet long.
16	1603	Montrose	47 45	48 08	Very large berg.
16	1604	do	47 44	48 05	Large berg.
16	1605	do	47 56	47 19	Berg.
16	1606	do	47 49	47 02	Growler.
16	1607	City of Canberra	47 42	48 27	Large berg.
16	1608	Cape Race Station	48 06	49 09	Do.
16	1609	do	48 12	49 52	Do.
16	1610	do	48 11	50 20	Berg.
16	1611	Megantic	47 14	49 02	Small growler.
16	1612	do	47 18	48 41	Small growler and several pieces.
14	1613	Cape Race Station	46 58	51 10	Large berg.
14	1614	do	47 10	50 20	Do.
14	1615	do	47 15	49 40	2 bergs.
14	1616	do	47 27	49 40	Very large berg and several growlers.
14	1617	do	46 34	52 39	Several growlers.
17	1618	do	48 02	51 56	Large berg.
17	1619	do	48 18	51 29	Do.
17	1620	Melita	47 00	51 20	Berg.
17	1621	do	47 18	50 43	Large berg.
17	1622	Nova Scotia	47 52 to 48 02	51 35 to 51 00	6 bergs and 1 growler.
18	1623	Ice patrol	42 55	49 40	Growler.
18	1624	do	42 46	51 35	2 large bergs.
18	1625	do	42 46	52 19	Small berg.
18	1626	do	42 38	52 02	Berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 18	1627	Dutchess of Bedford	47 16	49 38	Berg.
18	1628	do	47 20	48 55	Do.
17	1629	Cape Race Station	47 17	52 12	Berg and 2 growlers.
17	1630	do	47 14	50 44	Berg.
18	1631	do	48 00	51 12	2 bergs.
18	1632	Iserholm	42 10	48 12	Large berg.
18	1633	Dutchess of Bedford	47 20	48 34	Berg.
18	1634	do	47 29	48 25	Berg and 2 growlers.
18	1635	do	47 32	48 12	Berg.
18	1636	Izarco	57 10	44 28	Red conical buoy carrying number 2.
18	1637	Calgaric	47 14	50 44	Large berg.
19	1638	Ice patrol	42 37	50 56	Berg.
18	1639	Cape Race Station	47 31	49 45	Do.
18	1640	do	47 27	48 34	2 bergs.
18	1641	do	47 43	50 44	Berg.
18	1642	do	47 38	48 20	Do.
18	1643	do	47 40	48 09	Do.
18	1644	do	47 10	52 03	Large berg.
18	1645	do	47 46	50 37	Berg.
18	1646	do	47 36	50 53	Do.
18	1647	do	47 24	51 45	Do.
18	1648	do	48 15	52 10	Growlers.
18	1649	do	47 25	49 35	Berg and growlers.
18	1650	do	47 43	49 45	Large berg.
18	1651	do	47 13	49 54	Do.
18	1652	Concordia	43 16	51 10	Berg.
19	1653	Letitia	48 14	48 11	Large berg.
19	1654	Ice patrol	42 50	51 30	2 bergs.
19	1655	do	42 53	52 13	Berg.
19	1656	do	43 00	52 40	Berg and growler.
18	1657	Cape Race Station	47 28	51 25	2 bergs.
18	1658	do	47 38	48 22	Berg.
19	1659	Collamer	42 13	48 23	Do.
19	1660	Levenbridge	45 25	49 27	Growler.
19	1661	Ice patrol	42 23	48 33	Berg, same as 1659.
19	1662	Cape Race Station	47 18	51 52	Berg.
19	1663	do	47 24	51 55	Do.
19	1664	do	47 20	51 32	Do.
19	1665	do	46 34	52 35	Do.
19	1666	do	47 00	49 29	Do.
19	1667	do	47 32	49 25	Do.
19	1668	do	47 38	49 06	Do.
19	1669	do	47 41	48 55	Do.
19	1670	do	47 34	48 55	Do.
19	1671	do	47 44	48 45	Do.
19	1672	do	47 54	48 52	Do.
19	1673	do	47 40	48 40	Do.
19	1674	do	47 58	48 38	Do.
19	1675	do	47 49	48 34	Do.
19	1676	do	47 44	48 38	Do.
19	1677	do	47 38	48 47	Do.
19	1678	do	47 49	48 55	Do.
19	1679	do	47 45	49 01	2 bergs.
19	1680	do	47 43	49 03	Berg.
19	1681	do	47 40	49 27	Do.
19	1682	do	47 35	49 29	Do.
19	1683	do	47 12	50 02	Do.
19	1684	do	47 00	51 00	Growlers.
19	1685	do	46 33	52 29	Do.
19	1686	do	48 14	47 41	Do.
19	1687	do	47 52 to 47 49	48 49 to 49 08	Many bergs and growlers.
19	1688	do	47 44	49 14	3 bergs.
19	1689	do	47 42	49 27	Berg.
19	1690	do	47 39	49 42	Do.
19	1691	do	47 31	52 46	Do.
19	1692	do	47 02	52 46	Do.
19	1693	do	47 14	52 44	Do.
19	1694	do	47 26	52 39	Do.
19	1695	do	47 24	52 41	Do.
19	1696	do	47 25	52 32	Do.
19	1697	do	47 31	52 35	Do.
19	1698	do	47 02	50 40	Large berg.
19	1699	do	46 32	52 25	Very large flat berg.
19	1700	do	47 55	50 45	Berg.
19	1701	do	48 08	50 29	Do.
19	1702	do	48 25	49 58	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north	Position: Longitude west	Nature of ice or obstruction
			° ′	° ′	
June 19	1703	Cape Race Station	47 45	51 05	7 bergs in vicinity.
19	1704	do	47 26	52 37	Several bergs.
19	1705	Ausonia	47 53	47 36	Berg.
20	1706	do	47 42	48 46	Do.
20	1707	do	47 56	47 51	Small berg.
20	1708	Doric	47 10	51 10	Large berg.
20	1709	Cape Race Station	48 10	49 24	Do.
20	1710	do	48 10	49 27	Large growler.
20	1711	do	48 20	49 30	Large berg.
20	1712	do	47 57	50 23	Berg.
20	1713	do	47 51	50 18	Do.
20	1714	do	47 31	50 39	Do.
20	1715	do	47 49	50 44	Do.
20	1716	do	47 44	50 51	Do.
20	1717	do	47 25	51 35	Do.
20	1718	do	46 40	52 40	Do.
20	1719	do	47 23 to 47 58	52 35 to 52 43	14 bergs.
20	1720	do	47 53	49 11	Large berg.
20	1721	do	47 49 to 48 20	52 47 to 50 45	14 bergs, many growlers.
20	1722	Doric	48 31	48 04	Large growler.
18	1723	Cairnross	47 20	51 45	Berg.
18	1724	do	47 28	51 35	2 bergs.
18	1725	do	48 15	50 10	Growlers.
20	1726	Cragpool	45 24	49 23	Small berg and growler.
20	1727	do	45 19	48 58	Berg and growler.
20	1728	Caledonia	47 35	49 22	Large berg and several growlers extending 5 miles north.
20	1729	do	47 13	50 35	Large berg.
20	1730	do	46 34	52 21	Large flat top berg.
20	1731	do	46 41	52 47	2 large bergs.
20	1732	do	46 34	52 43	Small berg.
20	1733	Montcalm	47 48 to 47 28	48 25 to 49 20	14 bergs and many growlers.
20	1734	Bothwell	47 48	48 05	Berg.
20	1735	do	47 59	47 31	Do.
20	1736	Montcalm	47 28 to 47 12	49 20 to 51 00	5 bergs.
20	1737	Cape Race Station	47 56 to 47 17	50 23 to 51 52	14 bergs north and south of track.
20	1738	do	47 37	50 42	Very large berg.
20	1739	do	47 53	47 25	Large berg.
20	1740	do	47 56	47 51	Small berg.
20	1741	do	47 42	48 46	Berg.
20	1742	do	47 30	49 28	Large berg.
20	1743	do	47 15	50 38	Small berg.
20	1744	do	46 30	52 20	Large berg.
20	1745	do	46 34	52 33	Small berg.
21	1746	Valfiorita	43 08	52 47	Large berg.
21	1747	do	42 55	51 45	1 small and 2 large bergs to north, 1 berg to south.
21	1748	Lake Gorin	43 14	48 36	Berg.
21	1749	do	43 09	48 42	Do.
21	1750	do	43 03	49 06	Berg and several growlers.
21	1751	Cape Race Station	46 32	52 48	Large berg.
21	1752	Carinthia	41 13	49 59	Large red conical buoy unlit.
21	1753	Ice patrol	42 42	48 06	Berg, same as 1659.
20	1754	Athenia	48 12	48 51	Growler.
20	1755	do	48 05	49 04	Berg.
20	1756	do	48 15	49 10	Do.
20	1757	do	47 45	49 10	Do.
20	1758	do	47 59	49 26	Do.
20	1759	do	48 07	49 38	Do.
20	1760	do	47 34	50 34	Do.
21	1761	do	46 53	52 42	Do.
21	1762	do	46 45	52 42	Do.
21	1763	do	46 43	52 43	Do.
21	1764	Brighton	46 00 to 46 00	47 44 to 48 00	3 low bergs.
21	1765	New York	41 22	49 57	Red conical buoy marked "2AFP."
21	1766	Lake Gorin	43 08	50 27	Berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
June 21	1767	Lake Gorin	43	02	50	31	2 bergs.
21	1768	do	43	08	50	42	Berg 60 feet high.
21	1769	Ice patrol	42	42	49	00	Berg.
21	1770	do	42	45	49	11	Large tabular berg.
21	1771	Valfiorita	42	41	49	56	Large and 2 small bergs.
21	1772	do	42	49	49	44	Berg.
21	1773	Lake Gorin	43	16	51	12	Do.
21	1774	do	43	21	51	20	Do.
21	1775	Valnegra	44	33	48	55	2 large bergs and several growlers.
21	1776	Schenectady	41	30	50	25	Red nun buoy marked "2AFP."
21	1777	Lake Gorin	43	04	51	25	Large berg.
21	1778	do	43	17	51	36	3 large bergs, same as 1747.
21	1779	do	43	05	51	48	Large berg, same as 1747.
21	1780	Valfiorita	42	33	49	08	Small berg, same as 1779.
21	1781	Montroyal	46	37	52	41	Large berg and several pieces.
21	1782	do	46	39	52	38	Large berg.
21	1783	do	46	45	52	39	Small berg.
21	1784	do	46	35	52	19	Large berg.
21	1785	do	47	06	51	45	Berg.
22	1786	do	47	29	50	13	Berg and pieces.
22	1787	Lituania	45	22	48	31	Berg.
22	1788	do	45	16	47	55	Do.
22	1789	Ice patrol	42	42	49	18	Berg, same as 1780.
22	1790	do	42	40	49	54	Small berg, same as 1782.
22	1791	do	42	35	50	02	Growler, same as 1781.
22	1792	do	42	35	50	10	Berg, same as 1781.
22	1793	do	42	38	49	08	Berg, same as 1779.
22	1794	Montroyal	48	01	49	24	Large berg and pieces.
22	1795	do	47	57	49	03	Do.
22	1796	do	47	50	48	58	Large berg.
22	1797	do	47	57	48	32	Do.
23	1798	Cold Harbor	42	20	49	23	Large berg, small berg 4 miles to eastward.
23	1799	Coelleda	43	15	49	20	Large growler.
23	1800	Villedys	45	26	47	56	Big berg.
22	1801	Wright	46	48	44	01	Berg.
22	1802	do	46	55	44	07	Small berg.
22	1803	Cape Race Station	48	16	51	30	Large berg 150 feet high, with 1 fairly large berg, 2 small bergs, and numerous growlers in vicinity.
22	1804	do	48	40	50	29	Large flat berg 60 feet high.
22	1805	do	48 00 to 47 30		47 50 to 50 00		Numerous bergs.
22	1806	do	46	35	52	24	Large berg and numerous growlers.
22	1807	do	46	41	52	42	Large berg.
23	1808	Ice patrol	42	37	50	12	Berg.
23	1809	do	42	46	50	39	Do.
23	1810	do	42	51	50	38	Large berg.
23	1811	do	43	06	50	21	Do.
23	1812	do	43	05	50	28	Berg.
23	1813	do	43	03	50	25	Growlers.
23	1814	do	43	11	50	36	Large berg.
23	1815	Cape Race Station	46	32	52	45	Do.
23	1816	Quaker City	43	31	51	39	Small berg.
23	1817	Cold Harbor	42	25	50	20	Berg with small berg 3 miles north, same as 1818.
23	1818	Ice patrol	43	24	51	09	Large berg.
23	1819	do	43	25	51	18	Large high berg.
23	1820	do	43	25	51	22	Small berg.
23	1821	do	43	29	51	31	Berg.
23	1822	do	43	29	51	42	Large flat-topped berg.
23	1823	Cold Harbor	42	37	50	51	Berg.
23	1824	do	43	05	50	35	Do.
23	1825	Coelleda	43	13	51	14	Large low growler.
23	1826	Quaker City	44	10	48	48	Berg.
23	1827	Waukegan	42	20	49	20	Berg, same as 1808.
23	1828	do	42	24	49	05	Do.
23	1829	Ice patrol	42	59	51	46	Large berg.
23	1830	do	42	53	51	57	Do.
23	1831	do	43	03	52	10	Large low berg.
23	1832	do	42	44	52	09	Berg.
23	1833	Cold Harbor	42	27	51	42	3 bergs to northwest 10 to 15 miles, same as 1839–41.
23	1834	Ice patrol	42	53	51	36	Berg.
23	1835	Cold Harbor	42	33	52	11	Small berg.
23	1836	Ice patrol	42	55	51	24	Berg.
23	1837	McKeesport	42	48	48	00	Large berg.
23	1838	Coelleda	43	19	51	38	Berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position				Nature of ice or obstruction
			Latitude north		Longitude west		
			°	′	°	′	
June 23	1839	Coelleda	43	21	51	44	Berg.
23	1840	do	43	18	51	47	Growler.
23	1841	do	43	24	51	54	Berg.
23	1842	do	43	24	51	50	Do.
23	1843	do	43	06	51	57	Do.
23	1844	do	43	06	52	00	Do.
23	1845	do	43	15	52	02	Growler and small pieces.
23	1846	do	43	05	52	05	Berg.
23	1847	do	43	08	52	24	Small berg.
23	1848	do	43	07	52	40	Do.
23	1849	Cape Race Station	47	00	47	38	8 bergs within radius of 5 miles.
23	1850	do	47	05	48	14	Berg.
23	1851	Leviathan	41	21	50	20	Buoy marked "2AFP."
24	1852	Bird City	42	38	48	38	Berg.
24	1853	Aurania	46	56	51	38	Do.
24	1854	Beaverford	47	12	50	32	Do.
24	1855	Bird City	42	00	50	00	Large berg.
24	1856	do	42	20	49	18	Large berg and small berg.
24	1857	Cape Race Station	47	20	49	37	Berg.
24	1858	California	48	18	49	09	Do.
24	1859	do	47	44	50	02	Do.
24	1860	do	47	37	50	07	Do.
24	1861	do	46	36	50	25	Do.
24	1862	do	47	34	50	27	Do.
24	1863	do	47	44	50	37	Do.
24	1864	do	47	24	50	45	Do.
24	1865	do	47	21	50	51	Do.
24	1866	do	47	37	50	52	Do.
24	1867	do	47	30	51	03	Do.
24	1868	do	47	37	51	06	Do.
24	1869	do	47	37	51	08	Do.
24	1870	do	47	27	50	41	Growler.
24	1871	do	47	36	50	25	Many growlers.
24	1872	do	47	21	51	30	Berg.
24	1873	do	47	22	51	31	Do.
24	1874	do	47	16	51	25	Do.
24	1875	do	47	03	51	53	Berg and growlers.
24	1876	Ice patrol	43	02	52	18	Berg.
24	1877	do	42	48	52	13	Do.
24	1878	do	42	55	52	03	Do.
24	1879	do	43	04	50	52	Do.
24	1880	do	43	00	50	33	Do.
24	1881	Ausonia	47	07	51	15	Do.
24	1882	do	47	17	50	56	Very large berg.
24	1883	do	47	13	50	34	Small berg.
24	1884	do	47	08	50	21	Berg.
24	1885	do	47	06	50	20	Growler.
24	1886	do	47	30	50	00	Berg.
24	1887	Bird City	42	51	48	25	Large berg.
24	1888	Svendal	43	30	49	16	7 large bergs.
24	1889	Beaverford	47	20	49	37	Small berg.
24	1890	do	47	25	49	03	3 small growlers.
24	1891	do	47 26 to 47	35	48 56 to 48	15	13 large scattered bergs.
24	1892	Ice patrol	42	24	50	00	Large growler.
24	1893	do	42	18	49	50	Small berg.
24	1894	California	46	55	52	05	Do.
24	1895	Aurania	47	22	49	38	Berg.
24	1896	do	47	23	49	35	Growler.
24	1897	Beaverford	47 45 to 47	38	47 35 to 47	58	4 scattered bergs.
24	1898	Cape Corso	43	03	52	55	Large berg.
24	1899	do	43	00	53	03	Berg.
24	1900	do	42	57	53	00	Do.
24	1901	do	42	55	52	35	Do.
24	1902	Svendal	43	30	49	16	Large berg, same as 1898.
24	1903	Cape Race Station	47 07 to 47	26	50 41 to 51	38	7 bergs and some growlers.
24	1904	do	46	44	51	10	2 small bergs.
24	1905	do	46	49	52	14	Growler.
24	1906	do	47	00	51	39	Berg.
24	1907	do	47	10	51	22	Do.
24	1908	do	47	21	50	49	Do.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north ° ′	Position: Longitude west ° ′	Nature of ice or obstruction
June 24	1909	Cape Race Station	47 33	50 26	2 large bergs.
25	1910	Veendam	47 44	48 25	Berg.
25	1911	Ausonia	47 38	48 37	Do.
25	1912	do	47 35	48 27	Do.
25	1913	Maria Mediaca	45 21	48 10	7 bergs.
25	1914	Cape Corso	42 05	49 48	Large berg.
25	1915	Montclare	47 53	48 42	Large berg and many bergy bits.
25	1916	Veendam	46 55	51 32	Berg.
25	1917	do	46 57	51 39	Do.
25	1918	do	46 33	52 11	Do.
25	1919	Transylvania	46 13	52 45	Do.
25	1920	do	46 22	52 32	Do.
25	1921	do	46 34	52 27	Do.
25	1922	Bellhaven	46 25	47 20	Large berg.
25	1923	Metagama	46 56	51 38	Do.
25	1924	do	46 58	51 32	Do.
25	1925	Cape Race Station	46 32	52 53	Large flat berg.
25	1926	do	48 04 to 47 15	49 50 to 51 28	8 bergs and some growlers on both sides of track.
25	1927	Transylvania	46 32	52 16	Large berg.
25	1928	do	46 53	51 43	Berg and growlers.
25	1929	do	46 55	51 46	Do.
25	1930	Montclare	47 29	50 05	Berg
25	1931	do	47 25	50 21	Do.
25	1932	do	47 22	50 33	Several small pieces.
25	1933	Metagama	47 37	50 00	Large berg.
25	1934	Transylvania	47 22	50 30	Numerous growlers.
26	1935	Carlsholm	47 19	51 34	1 large berg and 1 small berg.
26	1936	do	47 54	50 37	2 bergs.
26	1937	Cape Race Station	46 43	52 48	Berg.
26	1938	do	46 35	52 11	Very large berg.
26	1939	Minnedosa	47 25	50 21	Large berg.
26	1940	do	47 25	50 40	Do.
26	1941	do	47 27	50 49	Do.
26	1942	do	47 16	50 53	Berg.
26	1943	do	47 21	51 06	Large berg.
26	1944	do	47 07	51 32	Small berg.
26	1945	Cape Race Station	48 03	50 34	Large berg.
26	1946	do	47 54	50 44	2 bergs.
26	1947	do	47 38	50 32	Berg.
26	1948	do	47 42	50 42	2 bergs.
26	1949	do	46 46	52 03	Large berg.
26	1950	do	47 50	51 44	Berg.
26	1951	do	47 04	51 35	Do.
26	1952	do	47 00	51 23	Do.
26	1953	do	47 13	50 45	Large berg.
27	1954	Malaren	44 43	44 18	Berg.
27	1955	Cape Race Station	46 43	52 49	Do.
28	1956	Laurentic	47 47	49 52	Do.
27	1957	Empress of Australia	47 13	50 40	Do.
27	1958	do	46 52	51 39	Growler.
27	1959	do	46 51	51 43	Berg.
27	1960	do	46 49	51 50	Do.
27	1961	do	46 34	52 52	Growler.
27	1962	do	46 33	52 56	Berg.
27	1963	Munchen	41 30	50 25	Red conical buoy marked "2AFP."
28	1964	Laurentic	47 52	50 09	Small berg.
28	1965	do	47 30	50 41	Do.
28	1966	do	47 32	50 47	Do.
28	1967	do	47 31	50 52	Medium berg.
28	1968	do	47 17	50 44	Large berg.
28	1969	do	47 28	51 04	1 large berg, 1 small berg.
28	1970	do	47 19	51 06	Small berg.
28	1971	do	47 13	51 03	Large berg.
28	1972	Arabic	48 02	46 50	Small berg.
28	1973	do	47 44	49 20	Large berg.
28	1974	Svithiod	42 27	49 06	Small berg.
27	1975	Cape Race Station	46 30	53 00	Berg aground.
28	1976	Arabic	47 32	49 45	Large berg.
28	1977	Cape Race Station	46 43	52 49	2 bergs drifting south.
28	1978	Arabic	47 34	49 47	Growler.
28	1979	do	47 25	50 08	Berg.
28	1980	do	47 31	50 24	Do.
28	1981	do	47 33	50 26	Do.
28	1982	do	47 31	50 30	Small berg.
28	1983	do	47 31	50 40	Berg.
28	1984	Alf	46 05	52 47	Large berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north (° ′)	Position: Longitude west (° ′)	Nature of ice or obstruction
June 28	1985	Arabic	47 47	51 08	Berg.
28	1986	do	47 10	51 38	Berg and growler.
28	1987	do	46 53	51 46	Berg.
28	1988	do	46 55	51 52	Do.
28	1989	do	46 38	52 30	Large berg.
29	1990	W. D. Anderson	42 32	48 36	Small berg.
29	1991	Santa Aurora	42 18	50 21	Do.
29	1992	Ice patrol	42 26	50 12	Berg.
29	1993	Cape Race Station	46 44 to 46 34	52 44 to 52 53	5 bergs.
29	1994	Nortonian	45 44	48 28	Large berg.
29	1995	Ellen	46 16	47 06	Scattered small bergs.
29	1996	do	46 18	47 29	Berg 660 feet long 170 feet high.
29	1997	Nortonian	46 12	47 02	Bergs and growlers, same as 1995.
29	1998	do	46 10	46 56	Large berg.
29	1999	Cape Race Station	46 49	51 30	Berg.
29	2000	Nortonian	45 47	48 08	2 large growlers.
29	2001	do	45 56	47 55	Large berg and several growlers.
29	2002	do	45 57	47 50	Small berg.
29	2003	do	46 12	47 24	Large berg, same as 1996.
29	2004	Cape Race Station	46 42	51 42	Berg.
29	2005	do	46 34	52 07	Do.
29	2006	Montcalm	46 31	52 50	Large berg.
29	2007	do	46 49	52 50	2 large bergs.
29	2008	do	46 32	52 14	Large berg.
29	2009	do	46 44	51 44	Berg.
29	2010	do	46 48	51 28	Large berg.
29	2011	Edderheim	42 08	52 28	Berg and growlers.
30	2012	Montcalm	47 26	48 54	Berg.
30	2013	Tiguca	44 20	48 30	Do.
30	2014	Ville Dys	44 20	49 30	Mast of a sailing vessel.
30	2015	Montcalm	48 12	45 30	Berg.
30	2016	Winnebago	45 30	47 12	Do.
30	2017	do	45 30	47 12	Do.
30	2018	Cape Race Station	46 38	52 51	Do.
30	2019	do	47 03	51 40	Do.
30	2020	do	47 04	51 39	Do.
30	2021	do	47 13	51 14	Do.
30	2022	do	47 30	50 53	Do.
30	2023	do	47 21	50 39	Do.
30	2024	do	47 26	50 32	Do.
30	2025	do	47 31	50 27	Do.
30	2026	do	47 50	50 08	Do.
30	2027	do	47 54	49 52	Do.
30	2028	do	47 43	49 47	Do.
July 1	2029	Lancastria	40 26	58 55	Buoy about 12 feet high, with frame structure and light.
1	2030	Cape Race Station	47 52	51 42	2 bergs.
1	2031	do	48 00	51 46	Do.
1	2032	Maroc	43 50	51 40	Berg.
1	2033	do	43 50	51 47	Do.
2	2034	Cape Race Station	46 35	52 44	Do.
2	2035	do	46 36	52 43	Growler.
2	2036	Calgaric	47 23	51 47	Berg.
2	2037	do	47 23	51 43	Large growler and several small ones.
3	2038	Cape Race Station	47 45	51 20	Large berg.
3	2039	Reliance	41 03	46 20	Wreckage of wooden ship not visible above surface.
3	2040	Ice patrol	43 03	53 07	Berg and growlers.
4	2041	Port Darwin	43 09	49 22	2 bergs and 1 growler.
3	2042	Cape Race Station	46 25	52 49	Large berg.
3	2043	do	46 22	52 42	Berg.
3	2044	do	46 39	52 51	Do.
3	2045	do	46 42	52 43	Do.
4	2046	Port Darwin	43 08	48 49	Berg 15 feet high 150 feet long and several growlers.
4	2047	do	43 04	48 49	Berg.
4	2048	Cape Race Station	47 54	50 55	Large berg and 6 growlers.
4	2049	do	47 45	50 00	Berg.
4	2050	do	47 38	50 15	Growler.
4	2051	do	47 35	50 20	Berg and growlers.
4	2052	do	47 33	50 24	Do.
4	2053	do	46 30 to 46 43	52 51 to 52 49	4 bergs.
4	2054	Ice patrol	42 26	50 00	Large berg.
4	2055	do	42 31	50 00	Small berg.

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north		Position: Longitude west		Nature of ice or obstruction
			°	′	°	′	
July 4	2056	Letitia	48	12	49	40	Berg.
4	2057	do	47	48	50	03	Berg, same as 2049.
4	2058	Ice patrol	42	04	49	34	Berg.
4	2059	Malmen	41	51	49	33	Small berg, same as 2058.
5	2060	Ice patrol	42	05	49	33	Do.
4	2061	Cape Race Station	47	28	51	42	Berg.
4	2062	do	47	38	51	23	Do.
4	2063	do	47	50	51	08	Do.
4	2064	do	47	52	50	34	Do.
4	2065	do	47	58	50	31	Several small pieces.
4	2066	do	48	13	50	12	Large berg.
4	2067	do	48	30	49	57	Do.
4	2068	do	46	23	52	10	Do.
4	2069	do	46	41	52	20	2 large bergs.
4	2070	do	46	42	52	32	Large berg several growlers.
4	2071	do	48	19	49	45	Small berg.
4	2072	do	48	25	50	14	Large berg.
4	2073	do	48 26 to 47 33		50 02 to 52 32		17 large bergs and numerous growlers north and south of track.
5	2074	San Ugon	40	13	49	37	Buoy marked "FID US Survey" with white superstructure and white flag height above water about 15 feet.
5	2075	Lehigh	43	07	48	53	Large berg.
5	2076	do	43	00	48	59	Small berg.
5	2077	Cape Race Station	47	48	51	10	Do.
5	2078	do	48	04	50	24	Large berg.
5	2079	do	48	12	50	08	Do.
5	2080	do	46	29	52	57	Do.
6	2081	Ice patrol	42	24	49	51	Berg.
6	2082	Lehigh	42	42	53	33	Small berg in 67° water.
8	2083	Cameronia	48	06	48	13	Large berg.
8	2084	do	47	57	49	10	Do.
8	2085	do	47	40	50	00	Do.
7	2086	Cape Race Station	48	45	50	20	Do.
7	2087	do	48	25	50	54	Do.
7	2088	do	48	18	51	27	Berg.
7	2089	do	48	14	51	31	Do.
8	2090	do	46	30	52	45	2 growlers.
9	2091	Villarparosa	45	09	49	08	Large berg.
9	2092	Vittero Veneto	42	57	52	30	Do.
9	2093	Ice patrol	43	12	49	15	Berg.
9	2094	do	43	11	49	25	Do.
9	2095	Saguache	42	06	49	43	2 large bergs and 1 growler.
10	2096	Gripsholm	48	30	50	04	2 bergs and 1 growler.
10	2097	do	48	11	51	10	Berg.
10	2098	do	48	02	51	06	Do.
10	2099	Ice patrol	42	57	49	38	Small berg, same as 2093.
10	2100	do	43	03	49	42	Berg, same as 2094.
10	2101	do	42	35	49	52	Small berg.
10	2102	Koranna	42	15	49	30	Berg.
10	2103	Hofuku Maru	46	19	53	01	Large berg 200 feet high.
10	2104	Cape Race Station	46	18	52	47	Large berg.
10	2105	Koranna	42	32	49	54	Large berg, same as 2101.
10	2106	Gripsholm	47	01	52	30	Berg 135 feet high.
10	2107	Vittorio Veneto	41	55	49	30	2 large bergs.
10	2108	do	41	50	49	02	Berg.
10	2109	do	41	48	49	01	Berg and growler.
10	2110	Brazil	46	42	52	08	2 growlers.
10	2111	Ice patrol	41	55	49	25	2 bergs, same as 2107.
10	2112	Koranna	42	37	50	20	Berg.
10	2113	Dordrecht	41	44	49	04	2 large bergs, same as 2108–09.
10	2114	Ice patrol	41	44	49	00	2 bergs, same as 2113.
10	2115	Consul Olson	45	03	49	02	Berg.
11	2116	Ragnhildsholm	44	15	49	11	Do.
11	2117	Pennland	48	39	45	14	Large berg.
11	2118	Transylvania	46	47	52	12	Low-lying berg.
11	2119	Pennland	48	04	47	17	Large berg.
11	2120	Stuttgart	41	21	48	43	2 large bergs and several growlers.
10	2121	Cape Race Station	48	53	50	17	Berg.
10	2122	do	48	34	50	11	Do.
10	2123	do	47	45	51	09	Do.
10	2124	do	47	46	51	24	Do.
10	2125	do	47	38	51	40	Do.
11	2126	Manchester Hero	41	30	48	40	2 bergs, same as 2107.
11	2127	Hofuku Maru	46	00	47	17	Large berg.
11	2128	do	45	55	47	16	Do.
11	2129	do	45	52	47	16	Do

Table of ice and other obstructions, 1929—Continued

Date	No.	Reported by—	Position: Latitude north °	′	Position: Longitude west °	′	Nature of ice or obstruction
July 11	2130	Hofuku Maru	45	50	47	12	Berg.
11	2131	Capricorne	44	55	54	10	2 bergs.
11	2132	United States	42	00	50	10	Small berg, several growlers.
11	2133	Kearney	42	31	50	04	Small berg and 2 growlers.
11	2134	Ice patrol	41	39	48	38	Large berg same as 2113.
11	2135	do	41	36	48	32	Do.
11	2136	Piako	41	23	48	36	Large berg with 2 peaks, same as 2113.
11	2137	Cape Race Station	46	17	52	00	Large berg 80 feet high.
12	2138	Rochambeau	41	44	49	50	Large berg.
12	2139	Ice patrol	41	30	48	15	Large berg, small berg, and several growlers, same as 2113.
12	2140	Bergensfjord	48	16	49	49	Berg.
12	2141	do	47	46	50	42	Do.
12	2142	do	47	43	50	56	Do.
12	2143	do	47	44	50	48	Do.
12	2144	do	47	35	51	48	Do.
12	2145	do	47	27	52	05	Do.
12	2146	Invergoil	49	55	45	17	Wooden skeleton 15 feet high marked "FID US Survey" with 2 flags.
13	2147	Lackawanna	41	57	49	43	Small berg.
13	2148	Artigas	45	58	47	08	2 bergs.
13	2149	do	45	26	48	55	Berg and 2 growlers.
13	2150	Ice patrol	42	13	48	35	Berg, same as 2113.
13	2151	do	41	41	48	30	Small berg.
13	2152	do	41	45	48	32	2 growlers.
13	2153	Sergeant Gouarme	43	30	49	10	Large berg.
14	2154	Lake Benbow	41	36	48	11	Large berg and several growlers.
13	2155	Cape Race Station	42	52	50	00	Berg.
13	2156	do	45	32	48	56	4 bergs and growlers.
13	2157	do	45	15	54	55	Berg.
13	2158	do	48	20	49	42	Do.
13	2159	do	48	36	50	09	Do.
13	2160	do	46	33	53	05	Do.
14	2161	Tuscania	40	15	46	03	White buoy marked "FID US Survey" with tripod superstructure black cage and blue and white flags.
14	2162	Ice patrol	41	33	48	05	Berg.
14	2163	do	41	44	48	44	Growler.
14	2164	Lake Benbow	41	24	49	38	3 large bergs.
14	2165	Hagno	43	33	48	09	Small berg.
14	2166	Scythia	46	33	52	56	Large berg.
14	2167	do	46	57	52	08	Berg.
15	2168	do	47	47	49	13	Do.
15	2169	do	47	58	48	59	Large growler.
15	2170	do	48	12	49	00	Large berg.
14	2171	Saco	41	28	49	28	2 bergs, same as 2164.
15	2172	Ice patrol	41	34	48	58	Large berg and growlers, same as 2164.
15	2173	do	41	34	48	53	Berg, same as 2164.
15	2174	Cape Race Station	47	51	51	00	Berg.
15	2175	Westphalia	41	44	49	34	Growler.
15	2176	Schenectady	42	13	50	34	Large berg, 3 growlers.
15	2177	Cape Race Station	47	24	52	24	Large berg.
15	2178	do	46	57	52	20	Do.
15	2179	do	48	39	50	20	Do.
15	2180	do	48	33	50	31	Do.
15	2181	do	48	29	50	52	Small berg.
15	2182	do	48	14	50	48	Large berg.
15	2183	do	46	33	53	00	Berg aground.
15	2184	Scythia	48	07	48	32	Berg.
15	2185	do	48	12	48	16	Large berg.
16	2186	Ice patrol	41	43	48	50	Berg, same as 2164.
16	2187	do	41	46	48	40	Do.
16	2188	Ellin	43	51	49	15	Berg.
17	2189	Koenig	42	07	50	11	Large berg and 4 growlers.
17	2190	Alexandre Andre	41	39	48	24	Large berg, same as 2164.
17	2191	do	41	31	48	38	Do.
17	2192	Ice patrol	41	45	48	40	Berg, same as 2164.
17	2193	do	41	43	48	27	Small berg, same as 2164.
17	2194	do	42	08	49	42	Large berg.
17	2195	West Arrow	46	10	46	00	Growler.
17	2196	Cape Race Station	46	28	53	05	Berg drifting south.
17	2197	Hallaren	48	27	50	01	Berg.
17	2198	Drachenfels	43	35	49	14	Large berg 40 to 45 feet high.
17	2199	Henri Jaspar	42	24	49	09	Growler.
16	2200	Doric	51	20	57	15	Large berg.
16	2201	do	51	23	57	03	Berg.
16	2202	do	51	26	56	54	Do.
16	2203	do	51	46	55	49	Large berg.

Table of ice and other obstructions, 1929—Continued

Date		No.	Reported by—	Position				Nature of ice or obstruction
				Latitude north		Longitude west		
				°	′	°	′	
July	16	2204	Doric	51	43	55	44	Berg.
	16	2205	do	51	50	55	39	Small berg.
	16	2206	do	51	52	55	32	Berg.
	16	2207	do	51	51	55	25	Large berg.
	16	2208	do	51	52	55	17	Do.
	16	2209	do	52	00	55	30	4 large bergs.
	16	2210	do	52	05	54	49	2 large bergs.
	16	2211	do	51	58	54	33	1 large berg.
	18	2212	do	52	57	50	54	Do.
	18	2213	do	52	46	50	54	2 growlers.
	18	2214	Caledonia	48	17	48	30	Berg.
	18	2215	do	48	06	49	04	Do.
	18	2216	do	48	19	49	17	Large berg.
	18	2217	Ice patrol	42	28	50	05	Berg.
	18	2218	Griesheim	48	50	48	38	Growler.
	17	2219	Cape Race Station	47	00	52	51	Large berg.
	17	2220	do	47	11	52	50	2 bergs.
	17	2221	do	47	11	52	40	2 small bergs and growlers.
	17	2222	do	47	18	52	45	Berg.
	18	2223	do	46	26	52	56	Large berg.
	18	2224	Ice patrol	42	03	49	31	Large berg, same as 2194.
	18	2225	Hellig Olaf	41	49	48	16	Berg, same as 2192.
	18	2226	Clara	39	58	53	08	Black buoy with a structure 15 feet high.
	11	2227	Cape Race Station	47	00	30	34	Wreckage of schooner hull 40 feet long 20 feet wide.
	19	2228	Phyrcania	39	46	53	30	Red buoy.
	19	2229	Ice patrol	42	06	49	28	Large berg, same as 2194.
	19	2230	do	41	57	48	22	Small berg, same as 2192.
	19	2231	Cape Race Station	47	15	47	20	Large berg.
	19	2232	do	48	23	51	01	Large berg and 2 growlers.
	19	2233	Tiger	46	30	52	50	Berg.
	20	2234	Ice patrol	42	10	48	23	Growler.
	20	2235	Byron	41	09	48	42	Small berg.
	20	2236	Gripsholm	46	23	52	41	Berg.
	20	2237	Baron Dalmeny	41	49	49	53	Large berg.
	21	2238	Vimeira	42	40	49	44	Do.
	21	2239	Transylvania	46	25	52	42	Berg, same as 2236.
	21	2240	Cambridge	46	21	52	43	Do.
	21	2241	Mercer	41	45	49	43	Berg 75 feet high with growlers extending 2 miles to south.
	21	2242	Seattle Spirit	48	23	45	52	Large berg.
	21	2243	Dakarian	41	42	49	42	Large berg and several growlers.
	21	2244	Seattle Spirit	48	02	46	41	Large berg and growlers.
	22	2245	Szeldedyk	41	55	49	32	Large berg.
	22	2246	do	41	44	49	35	Do.
	22	2247	Paul Albert	43	20	50	40	Berg.
	22	2248	Ice patrol	42	00	49	32	Large berg, same as 2245.
	22	2249	do	42	34	49	47	Berg.
	22	2250	Scandia	45	45	45	14	Large berg.
	22	2251	do	45	44	45	47	Small berg.
	23	2252	Olna	42	36	49	48	Large berg, same as 2249.
	23	2253	Ice patrol	41	49	49	18	Small berg.
	23	2254	do	42	10	49	28	Berg.
	23	2255	Scandia	42	57	49	20	Berg and growler.
	23	2256	Jenny	41	51	49	19	Large berg.
	23	2257	do	41	56	49	18	Do.
	23	2258	United States	42	10	49	30	Do.
	23	2259	do	41	55	49	20	Small berg.
	23	2260	Scandia	42	31	49	46	Berg.
	23	2261	Cape Race Station	48	18	50	38	2 large bergs.
	24	2262	Olna	42	43	49	37	Berg.
	24	2263	Aquitania	41	47	49	15	Growler, same as 2253.
	24	2264	Ice patrol	41	54	49	16	Do.
	24	2265	do	42	11	49	29	Berg, same as 2254.
	24	2266	Cape Race Station	48	40	49	45	Large berg.
	25	2267	Dresden	41	34	54	40	Big mast with yard.
	25	2268	Ice patrol	42	14	49	30	Berg, same as 2254.
	25	2269	Arabic	48	06	47	06	Large berg.
	26	2270	Albertic	48	28	48	47	Very large berg.
	26	2271	Ice patrol	42	20	49	45	Growler, same as 2254.
	27	2272	City of Hankow	44	58	48	34	Large berg.
	27	2273	Cape Race Station	48	02	46	47	Very large berg 100 feet high.
	28	2274	do	47	10	46	40	Large berg.
	28	2275	Westphalia	40	31	54	13	Open fishing boat marked "Nr. 2."
	29	2276	Cape Race Station	49	04	49	45	Berg.
	29	2277	do	48	46	50	42	Large berg.
Aug.	1	2278	Frederic VIII	48	28	49	40	Berg.
	3	2279	Cape Race Station	47	52	52	39	Do.

WEATHER

Throughout the 1929 ice-patrol season the vessels actually on patrol remained within 120 nautical miles of 42° 30′ N., 49° 30′ W. That position, therefore, can be taken for all practical purposes as the place where the observations, which are described below, month by month, were made. But too much stress should not be placed on this position, for the weather experienced by the ice-patrol vessels depends to a very great extent on their location in the ice-patrol area. The northern part of the area cruised in is often cold and foggy because of Labrador Current water, while, at the same time, the near-by southern part of the ice-patrol area is warm and sunny because of Gulf Stream influence. In comparing figures like average air temperatures and fog percentages of any one month with those of the corresponding month in previous years, or of other months of the same year, the fact should not be lost sight of that warmer and clearer conditions recorded may be due not so much to actually different conditions in the region as a whole as to whether or not the patrol vessels remained in the colder or warmer parts of the ice area during the greater part of the time under consideration.

The weather diagrams for each month of the active patrol season show graphically the wind directions and forces averaged for each 12 hours, the barometric curve, and the time and duration of fog and low visibility. In addition, the maximum, minimum, and average air temperatures, as well as percentages of the time that bad and poor visibility prevailed, have been given for each patrol month. As these figures were obtained in exactly the same manner as the corresponding ones for last year, the remarks made regarding them on page 50 of the 1928 Ice Patrol Bulletin apply with equal force to this season's values.

APRIL

Maximum air temperature, 57° F.
Minimum air temperature, 30° F.
Average air temperature, 40° F.
Visibility was less than 4 miles 35 per cent of the time.
Visibility was less than 2 miles 26 per cent of the time.

The first ship to go out on the 1929 ice patrol left Boston, Mass., for the eastward on April 1 during the early stages of one of the four deep barometric depressions of the month. Winds of gale force were experienced on the second day out, but, fortunately for progress and fuel consumption, they came from a following direction. The temperature and fog figures given above are those from noon of the 3d to the end of the month. The values for the first two and a half days of April were disregarded because the patrol vessel did not get out into the real ice-patrol area conditions of weather until after that time.

The monthly weather diagram plainly shows that fog was almost entirely absent until the morning of the 18th. From then on to the last of the month there was so much fog and bad visibility, however, that the figures for the whole month are slightly above what has here been called normal for the time and region. There were two prolonged periods of fog, the first with a low barometer on the 18th, 19th, and 20th, and the second with comparatively high barometer on the 27th, 28th, 29th, and 30th. The latter period of thick weather was terminated on the 30th by a shift of wind to the westward which followed upon the passage, far to the north through the Strait of Belle Isle, of the center of a large cyclonic storm.

Throughout nine half-day periods the wind force averaged Beaufort 7 or greater. This shows more boisterous conditions than obtained during April, 1928, for then only five such periods were recorded. During two of the cyclonic disturbances very heavy swells were noted with waves at least 30 feet high. This height was estimated by noting when the ship was on an even keel in the trough between swells the height above the water line at which the line of sight ran off tangent to the tops of the seas.

When over the cold water, even during the periods of good visibility, morning and evening star sights could very seldom be obtained because of a typical stratus cloud formation, resembling a high fog, that was very frequently noted at certain hours. It was dark and heavy early in the morning, but gradually thinned out during the course of the forenoon. Around 10 a. m. a pale sun could be seen through the thinner parts, and at this time the first observations of the day could be taken, usually without the use of any shade glasses in the sextants. From about 11 a. m. to 3 p. m. sun sights could usually be taken at will, but as the afternoon progressed the rolling, fairly low, cloud layer would form again, blot out the blue sky, and gradually thicken until the sun's disk could be seen no more. This sort of cloudiness did not hamper the search for ice greatly, for the visibility usually remained excellent just over the sea, the lower limits of the fog or cloud keeping at a uniform moderate level at all times. The delay in fixing position was the most serious thing involved, preventing as it did prompt and accurate determination of ship's position, berg drifts, currents, and exact limits of areas fully searched.

MAY

Maximum air temperature, 56° F.

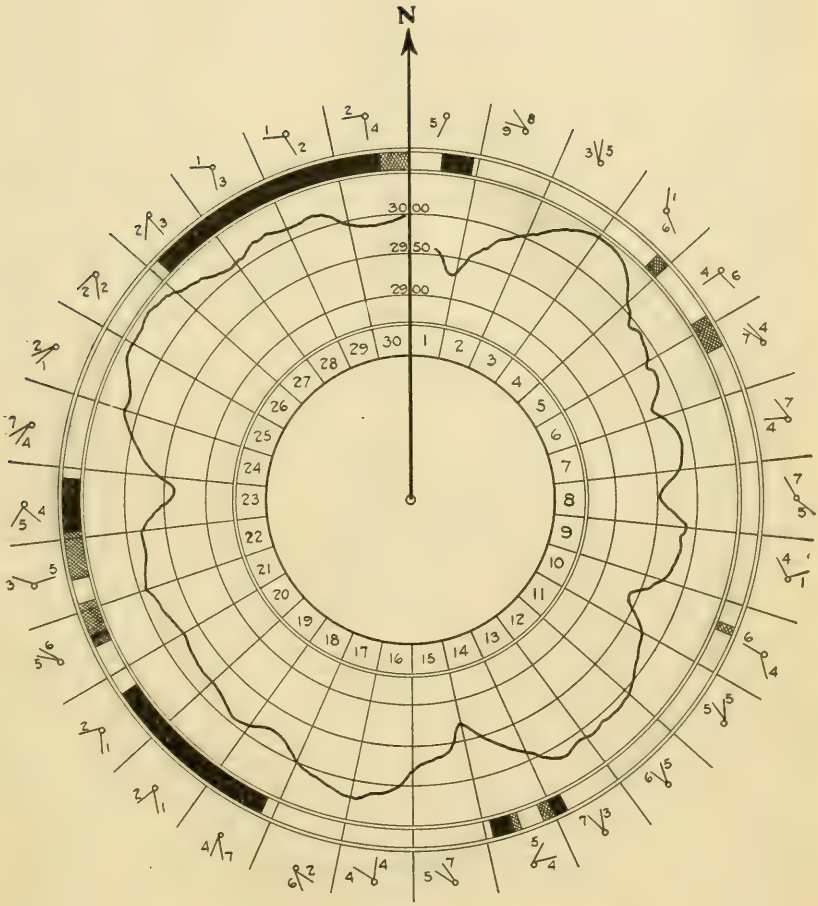
Minimum air temperature, 34° F.

Average air temperature, 42.9° F.

Visibility was less than 4 miles 34 per cent of the time.

Visibility was less than 2 miles 27 per cent of the time.

May, 1928, had about twice as much fog and bad visibility, as usual, but in 1929 the figures for the month were back to normal again.



APRIL WEATHER DIAGRAM
1929

VIS. 7, 8, & 9 = WHITE
VIS. 5 & 6 = CROSS HATCHED
VIS. 0, 1, 2, 3 & 4 = BLACK

FIGURE 2.—Inner figures show day of the month; the next band out contains the record of the atmospheric pressure; the next outer one indicates the degree of visibility (black areas for visibility of less than two sea miles and cross-hatched areas for visibilities of between two and four miles); the outer margin shows the average direction and force of wind per 12-hour periods, midnight to noon and noon to midnight. Wind directions are toward the small circle in each case. Arrow indicates true north

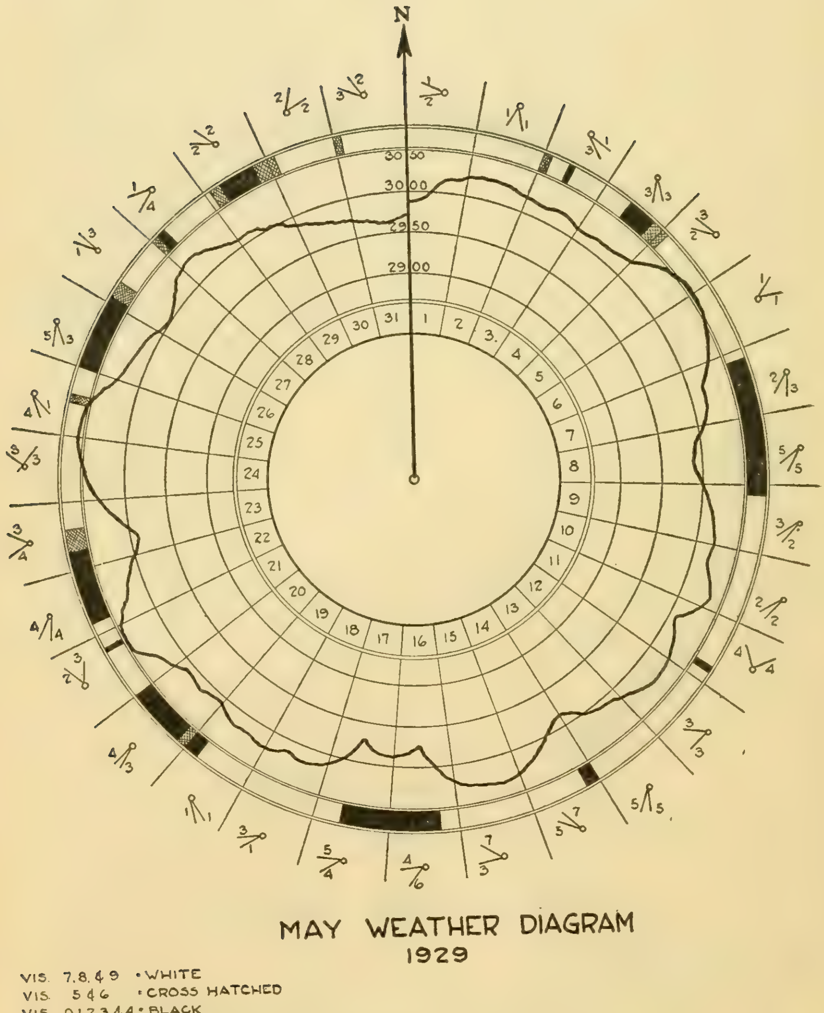


FIGURE 3.—For explanation of symbols, see Figure 2

The month was quite a pleasant one, taken as a whole. Air temperatures were quite low due to the unusual coldness of the ice-bearing waters, but there was much bright sunshine, and the air and sea temperatures slowly rose as the month advanced.

A few large cyclones passed northeastward across Newfoundland and Labrador, but the patrol vessels escaped all but the southern edges of these, and so had only two 12-hour periods of gales and no barometric pressure lower than 29.62, which figure was reached on the last day of the month. One feature noted on the weather maps made on board from synoptic data was a succession of large high-pressure areas that moved southeastward across the United States Atlantic Coast States and out to sea to join the Azorean High. Barometric pressures in the ice-patrol area became very high at times, exceeding 30.50 on five different days, which were invariably fine and sunny, though on two of these five days there was a slight haze that made bergs appear yellowish in the distance and disappear from sight when from 8 to 10 miles distant. Phenomenal visibility prevailed on the 2d, however, when the barometer was at 30.22 and light variable airs were blowing. At this time a berg about 50 feet high was seen from a height of eye of 30 feet when it was 38 sea miles distant.

The short period of fog experienced on the 11th with a high and rising barometer and north-northwest breezes was most unexpected. It occurred just before sunset over cold water near the junction of the Labrador Current and the Gulf Stream. The line of demarcation between the two waters was very ragged, for a little earlier in the day the patrol had cruised though alternate areas of cold and warm water each about 2 miles wide. The fog can best be explained by assuming that the surface air had just passed over a warm band of water and become moist and warm. A cold band of water happened to be to leeward of the warm band and, the critical conditions being just right, the moisture in the north-northwest breeze was condensed as fog as soon as the lowest layers of the warmed moistened air were chilled by contact with the small cold area in the sea. This unusual local fog occurred again on the 21st under almost identical conditions, except that in the second case the barometer was even higher, about 30.50 throughout the time. With northerly breezes fog is sometimes formed over the warm water, but its presence over cold water was very hard to explain.

Many other interesting meteorological phenomena were observed. For instance, the weather diagram shows that fog was finally caused on the 19th after southeasterly airs had been blowing for some time. As a general thing it takes a considerable time for southerly breezes to bring on a period of fog, and the further advanced the season is and the warmer the surface water is the harder it seems to be for the thick weather to get started.

When fog is formed over the cold water it is often very thin vertically with a clear blue sky showing overhead, as was the case on the 22d. Very often the rays of sunlight that reach the deck through the fog around midday have considerable warmth left in them, but not enough to remove the fog from the cold water as long as the wind continues to blow from warmer water toward colder. When conditions are rather finely balanced there is sometimes a tapering clear lane over the sea for a quarter of a mile or more directly to leeward of the drifting patrol ship, caused by the warmth escaping from the stack and hull.

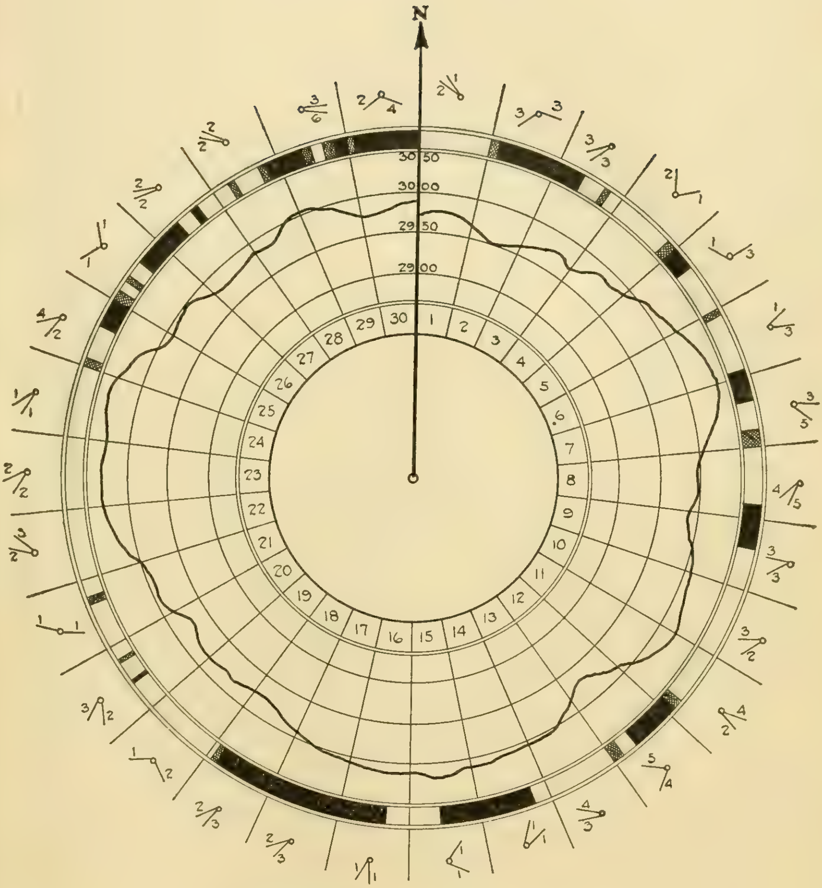
The weather cleared slowly on the 23d after a shift of wind to the northwest. By evening the atmosphere was remarkably clear to the westward and sunset was followed by a very distinct green flash at the spot on the horizon where the sun had just disappeared. The next day, with its high barometer and gentle breezes, was about the brightest, clearest, and finest day of the whole season.

JUNE

Maximum air temperature, 70° F.
Minimum air temperature, 38° F.
Average air temperature, 51.2° F.
Visibility was less than 4 miles 42 per cent of the time.
Visibility was less than 2 miles 34 per cent of the time.

June, as is quite normal, had a higher percentage of hours with fog than either of the two preceding months. There was a marked change to general summer weather conditions. The procession of "Lows" along the American coast and up the St. Lawrence Valley slowed down, and a great high-pressure area in the ocean east of the United States and southern Canada stood opposed to a fairly constant condition of low pressure over North America. This distribution of pressures always gives the Grand Banks region a large proportion of gentle but steady southerly breezes, which are over the colder water areas, accompanied by foggy weather. An even greater number of times than during May there was low-lying fog with clear or partly cloudy sky plainly visible overhead. The bright sunshine on some of the days made fogbows and allied phenomena of common occurrence.

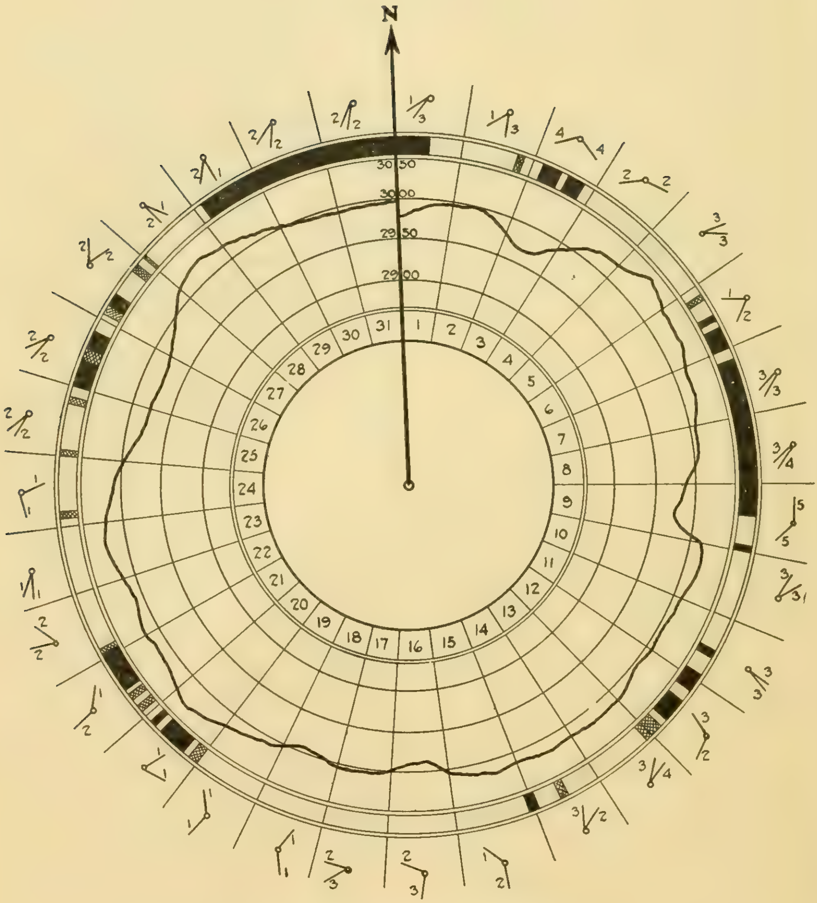
When cruising along the temperature wall many areas of fog patches were encountered. The search courses at such times frequently changed the surface water temperatures 11° F. in 11 minutes, say, from 48° F. to 59° F., and the air temperatures fluctuated almost as much and as rapidly. It would be raw and foggy over the cold water and damp and muggy over the warmer mixed water close by. During the first half of the month cold water pushed 150 miles to the southeastward to 40° N., 46° 40′ W., in a band about 20 miles wide. This stream was very difficult to search for ice because winds from



JUNE WEATHER DIAGRAM
1929

VIS. 7, 8 & 9 = WHITE
VIS. 5 & 6 = CROSS HATCHED.
VIS. 0, 1, 2, 3, 4. = BLACK.

FIGURE 4.—For explanation of symbols, see Figure 2



JULY WEATHER DIAGRAM
1929.

VIS. 7, 8, & 9 = WHITE
VIS. 5 & 6 = CROSS HATCHED.
VIS. 0, 1, 2, 3, & 4 = BLACK.

FIGURE 5.—For explanation of symbols, see Figure 2

any direction except northwest came from warmer water areas and usually gave fog.

The lowest barometric pressure for the month, 29.50, was reached on the 2d, but this depression was unaccompanied by gales, there being only a few hours of fresh breezes while the wind was hauling through south to southwest. The whole month saw no full 12-hour periods of gales, but there was a near approach to one on the 29th, when the wind averaged force 6 between noon and midnight.

During a period of good visibility on the 4th, which was a drizzly, overcast day, a berg was sighted about 10 miles off. While it was being approached the cloud blanket shut down closer and closer to the sea. When the berg was finally reached it was seen that its upper parts were completely hidden in a fog. It was then noted that the patrol ship's topmast and crow's nest were also in fog, though visibility still remained good at sea level. In a short time the fog shut down completely. The wind was light from the north-northeast and the air temperature was 42° F. This case is mentioned because it is quite the opposite condition to that much more often experienced where the upper layers of the air remain clear and only the lower layers are foggy.

On the 9th the ship was in warm mixed water near the long southeast push of cold water mentioned above. It had been foggy, and after the wind hauled to the north of west it remained so, instead of quickly clearing as usual. In order that the good visibility which, it was thought, must exist near by might not be lost for searching purposes, the patrol stood to windward and in a short time entered cold water, over which there was no fog whatever. Over the region of warmer water to the southeastward the pall of fog could be seen hanging throughout the remainder of the day.

There was noticeably bad refraction on four days. On one a 40-foot berg was sighted 26 miles away, and a few hours later the sun went down not like a round ball of fire but greatly flattened, like a vertical section through a watch being lowered face uppermost into the sea. On another day double horizon lines were noted for some hours until continuing southerly breezes finally brought on fog and rain.

During several foggy days which were spent along the temperature wall, copious showers were experienced. Some of these were regular tropical downpours. From ship reports received, it is believed that at the same time bright weather was prevailing over the Gulf Stream drift, and the usual Grand Banks fog with clear sky overhead was prevailing farther north well inside the area of cold water. At other times, when cruising near the temperature wall, squalls from varying directions were experienced, all of which indicates that at times along the line of junction of Labrador Current and Gulf Stream there is

an unstable area, where uprushes of air, indrafts, and such activities take place.

JULY

Maximum air temperature, 73° F.

Minimum air temperature, 43° F.

Average air temperature, 59.8° F.

Visibility was less than 4 miles 38 per cent of the time.

Visibility was less than 2 miles 32 per cent of the time.

Previous to the 1929 season the ice patrol has always been discontinued by the middle of July, but the 1929 ice conditions necessitated its continuance until August 3. The July meteorological information given here and on the July weather diagram is, therefore, for the first time that for the full month. The patrol was discontinued so early in August that no separate discussion or weather diagram has been prepared for the time after July 31.

July was marked by very weak barometric gradients with accompanying fine moderate weather. The weather maps showed a tendency for a low-pressure area to remain over the central portions of North America and for high pressures to prevail over great areas of the North Atlantic Ocean and over the United States Middle Atlantic States. There was a marked increase in sea and air temperatures in the ice-patrol area because of continued solar warming, and a falling off in fog percentages as compared with the previous month. The last three days of the month were days of dense fog because of persistent southerly breezes and airs, and this fogginess was continued, over the colder waters along the eastern edge of the Grand Banks at least, without a break until after the patrol was discontinued on August 3. This shows that an advanced summer season, while it lessens the hours of fog over the warm and the warmed mixed waters, has but little beneficial effect over the southern reaches of the Labrador Current proper. It was often possible to pick clear-weather areas and to remain in them by working toward cold-water areas during northerly breezes and running toward warmer water when southerly breezes began to cause fog.

GENERAL REMARKS

Because much interest is shown by shipping in the patrol vessel's weather, the conditions prevailing were always incorporated in the routine ice broadcasts. Placing the data in these messages not only assured as wide a dissemination of it as possible but saved time and effort for all concerned through the cutting off of many inquiries regarding weather conditions that experience has shown would otherwise have come in from single vessels.

Twice daily a coded weather report was dispatched to the United States Weather Bureau, Washington, D. C., and at the end of each

cruise the regular Weather Bureau forms were filled in for the patrol period and mailed upon arrival in port. The coded dispatches to Washington always included, when available, the weather at one or more ship stations well separated from the patrol. These composite messages were transmitted direct to Washington at scheduled times which were sufficiently early to insure that the data would be available for use in making up the Weather Bureau's ocean forecasts. The same weather information sent to Washington was transmitted via Canadian coastal radio stations to the Canadian meterological officials at Ottawa, Ontario, for their use. This was a new departure, beginning with the 1929 patrol season.

An average of 60 water-temperature reports were received each day from vessels within the ice-patrol area, which may be defined as the area bounded by latitudes 39° and 48° N. and longitudes 43° and 56° W. Shipping was frequently reminded of the need of the patrol for reports by broadcasts worded about as follows: "All vessels while within the ice-patrol area are requested to transmit to the ice-patrol vessel, call NIDK, the following every four hours: Ship's name, G. M. C. T., latitude, longitude, course, speed, temperature of water, weather conditions, and any ice or other obstructions sighted." In response many of the ships included in their water-temperature reports all the necessary meterological elements, for the most part, no doubt, very carefully and regularly observed. When a number of the best-cooperating ships were well scattered along the tracks there was a wealth of material to choose from, and most of the remaining time there were at least a few vessel reports to consider when making up the Weather Bureau dispatches. Only the latest, most reliable, and best situated reports were marked for coding and transmission to shore.

On the patrol vessels, especially during foggy periods, the weather obtaining at the positions of reporting vessels would be frequently plotted on suitable ocean charts. The limits of fog sheets, rain areas, good weather, gales, and other conditions could then be seen with considerable accuracy and ease. Detailed weather information obtained from reports so plotted was several times furnished the United States Weather Bureau officials on request during the anxious times just prior to projected trans-Atlantic airplane flights.

Following the customs of previous years, two weather maps were made up each day from data contained in the general synoptic broadcasts transmitted by NAA, at Arlington, Va. Supplemented by the weather reports received from shipping, these maps were used for forecasting the local weather. They proved most useful for use in connection with planning the patrol's cruising as well as interesting. With their aid it was always possible to know what weather conditions were prevailing in a large area to the westward. These conditions, it

is very soon clear to observers on the patrol ships, control to a great extent the immediate future course of weather in the ice-patrol area.

DEPTH SURVEY CARRIED OUT BY THE SONIC METHOD

Throughout the 1929 ice-patrol season both the *Tampa* and *Modoc* were equipped with commercial instruments for determining the depth of the water by sonic means. It was usually possible to use these instruments successfully so long as the ships remained inside the 1,400-fathom curve. On smooth days when the sets were working especially well they could be used in water up to about 2,000 fathoms deep. Whenever echoes could be obtained from the sea bottom frequent soundings were taken and recorded.

One hundred and ninety-one values that were obtained when the vessels' positions were well fixed by sights have been corrected for certain errors due to actual conditions of salinity, temperature, and pressure in the water column and forwarded to the United States Hydrographic Office and to the United States Coast and Geodetic Survey for use on charts of the North Atlantic Ocean. Altogether many times 191 values were recorded, but the great majority of soundings, though useful for immediate navigational purposes, were taken when the exact geographical position was in some doubt due to such things as abnormal refraction, cloudiness, darkness, and fog. The depths obtained when the position was uncertain were without exception discarded so far as giving them consideration for hydrographic use was concerned. The area where the patrol vessels cruised in 1929 has been rather well sounded out, and for this reason nothing but the best work of the season was considered worth keeping.

Two navigators worked out the different positions of the ships independently for check purposes, so the locations listed with the sounding values saved are based on double work and are believed to be as nearly correct as such values can be on board a ship on ice-patrol duty in the Grand Banks region. Of course some of the positions are closer to being right than others. The radius of error probably varies from next to nothing at all up to a maximum of about 10,000 yards.

ICE OBSERVATION

The varying ice conditions that existed during the first nine months of 1929 in the North Atlantic south of the forty-eighth parallel are discussed here. The monthly ice charts (figs. 6–11 inclusive) show plainly where the ice at different times was located with respect to the coast lines, principal steamship tracks, and other features of the Grand Banks region. They furnish a far better means than written remarks for comparing the change of ice conditions from month to month and those of certain months of one year with corresponding months of another. United States Hydrographic Office Miscellaneous Chart 2,511 was used as the base map for plotting all ice data.

Iceberg totals and ice conditions are based during the actual active patrol season on first-hand information, supplemented by that received by radio from ship and coast stations. Reports of ice published weekly in the United States Hydrographic Bulletin and those received from Canadian Government authorities are depended upon during the inactive season when there is no patrol ship in the vicinity of the Grand Banks.

The large number of ships on the various tracks that cooperate by reporting regularly makes much care necessary to keep duplications from unduly swelling the berg totals. Suppose, for instance, that 10 ships all pass along the same general line and each one reports four bergs to the patrol from about the same locations on the same day. Only one of these reports of ice can be considered for broadcast and statistical purposes, for it is obvious that all the ships have seen and reported the same ice.

Probable drift tracks of ice are rather well known from experience, and the general principles of these drifts are explained in conjunction with the charts on pages 68 and 69 of the Ice Patrol's Bulletin for 1927. In addition, particular detailed drifts and variations from the general rules can often be forecast after a study of the cruise isotherm and ice charts that are always kept up to date on the patrol vessels. Bergs reported from one position on one day, therefore, are frequently assumed to be identical with bergs reported from two or three and sometimes even five or six days earlier from different locations, and are eliminated from the statistical totals. But no reported berg is omitted from the broadcasts unless it is pretty definitely known to be identical with some other reported berg. It is certainly wiser to broadcast the presence of slightly more ice than exists rather than to eliminate from the reports mention of any ice that may still remain.

In accordance with the practice of all previous years, it was considered that the start of a new month cleared off the statistical slate, all bergs reported anew on or after the first of a month being considered once more for determination of monthly totals, whether or not they had already been reported.

Nine months instead of twelve are discussed here because complete ice information for the last three months of the year is not at hand as this section is being written. The 1930 Ice Observation and Ice Patrol Service pamphlet will contain the discussion for October, November, and December, 1929. As these three months share with January the distinction of being the very lightest ice months of the year, their omission from this publication is really of no moment.

Frequent reference is made throughout this and other sections to the "ice-patrol area." This never refers exclusively to the rather limited area south and east of the Tail of the Banks that can be physically covered by the efforts of the ice-patrol vessels themselves. It always includes all that area between the thirty-ninth and forty-eighth parallels and the forty-third and fifty-sixth meridians, which is constantly being crossed and recrossed by reporting vessels. In general, during clear weather all parts within these limits that are at all near the several steamship tracks are well covered either by the patrol or for it. During good weather conditions the situation may be said to be well in hand, and, therefore, advice can be given about ice conditions with confidence to vessels that may be crossing the ocean hundreds of miles to the north or the south of the actual limits of vision of the ice patrol. During the long periods of fog, however, when the eyes of reporting vessels as well as those of the patrol are blindfolded, the exact status of affairs with respect to the location of the ice is not so well known, and then extra precautions are regularly advised both in the broadcasts and in the special ice-information messages. The patrol's experience is that bergs can be detected only when they can be seen. It is only rarely that bergs are sighted or reported during thick weather or darkness, though undoubtedly the the brightest lookout is kept for them during just those times.

The ice-patrol area as defined above does not by any means set a bound to the patrol's interest, information, or service. Reports of ice and obstructions that come in from far to the eastward of the forty-third meridian and from far to the northward of the forty-eighth and even forty-ninth parallels are gladly received and when on hand are invariably included in the broadcasts. Far to the westward, also, the changing field-ice conditions in the approach to the Gulf of St. Lawrence are followed and reported as closely as the radio advices received make possible.

Water-temperature reports from the area surrounding the so-called ice-patrol area are also frequently received. They are always care-

PLATE X.—Medical officer of the *Tampa* on board a French fishing vessel off the eastern edge of the Grand Banks. There are between 20 and 30 men on each of these sailing vessels, and usually at least 1 member of the crew is in need of medical treatment. Complaints range from injuries and sores to abscessed teeth and tuberculosis

PLATE XI.—Dory pulling from a French fishing vessel to the *Tampa* with letters to be posted. The fishermen are frequently at sea for seven months at a stretch, and are always eager to send letters home and to exchange fish for articles of food which will add variety to their diet

PLATE XII.—For approximately one-third of the time the ice patrol cutters are blindfolded by dense fog like this. The fog is usually brought on by long continuing light southerly breezes. Often it is so thin vertically that the sun is able to shine down dimly to the water, as here

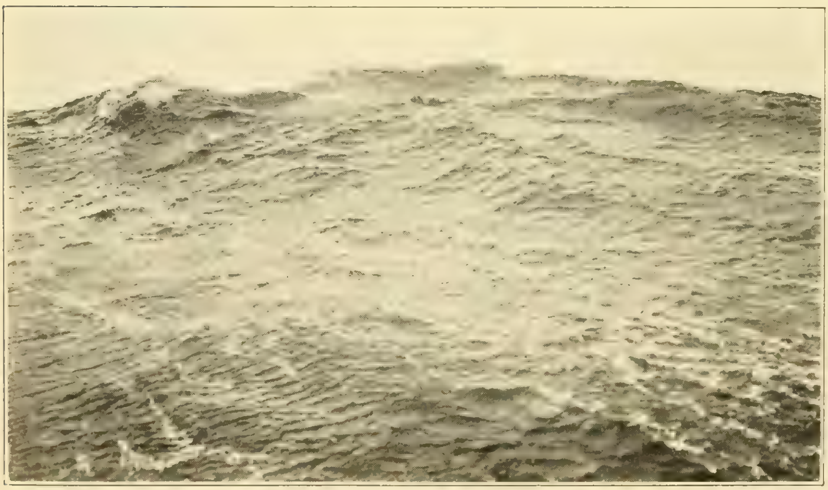


PLATE XIII.—There are a number of storms each season. These, as well as the fog, interfere with the scouting and scientific programs. This wave was photographed from the stern of an ice patrol cutter while not far from the tail of the Grand Banks

fully plotted and studied to see what bearing they may have upon ice, current, and weather conditions now obtaining or that may soon obtain within the area that is most intimately under the cognizance of the patrol.

JANUARY

There were no reports of ice from the region of the Grand Banks. Some field ice, however, was carried seaward from the Gulf of St. Lawrence by the Cape Breton Current and was reported during the latter part of the month from 60 miles southeast of Cape Breton.

FEBRUARY

Considerable field ice from the Gulf of St. Lawrence was reported from areas about midway between Sable Island and Cape Breton. Further east the first field ice of the season began to drift south into the international ice-patrol area proper, where it was reported frequently from the region just north of the Grand Banks. By the end of the month the southernmost limits of this latter ice had pushed south of the forty-seventh parallel along the line between Cape Race and the northeastern shoulder of the Grand Banks, and on the 28th there was a report of field ice and growlers extending south in the main branch of the Labrador Current along the eastern edge of the Grand Banks to 46° 25′ N., 47° 40′ W. So far as is known during this month no bergs drifted south of the forty-eighth parallel in company with the field ice from the north. The ice map for February, 1929, is almost identical with that for February, 1928.

MARCH

The ice map for this month also bears a remarkable resemblance to that for the corresponding period of the preceding year. The ice of March, 1929, being apparently somewhat heavier and of greater extent, however, gave the first hint that an unusually heavy ice season was about to develop. Vessels passing north of Sable Island reported large patches of loose field ice from the Gulf of St. Lawrence to be extending to about 120 miles southeast of Cape Breton. Some of these patches over the northeastern limits of Banquerau Bank were described as heavy.

Ten degrees to the eastward, along the eastern edge of the Grand Banks, the first bergs of the season began to be reported wherever the trans-Atlantic traffic sighted the southward moving field ice. Indeed, throughout most of the area northwest of the line from Cape Race to Flemish Cap and on both sides of the line from Flemish Cap to 44° 30′ N., 49° 00′ W., field ice and bergs were frequently reported together.

APRIL

No reports were received of the Gulf of St. Lawrence field ice but in the Labrador Current along the eastern edge of the Grand Banks there appeared a far greater amount of all kinds of ice than usual for the season. In the first place a great amount of field ice seriously obstructed navigation within the area partially bounded by lines running from Cape Race to 44° 20′ N., 48° 30′ W., thence to 47° 30′ N., 46° 30′ W., and thence northwestward past the forty-ninth parallel, and so out of the field of observation. Everywhere this field ice was more or less thickly studded with bergs.

Toward the end of the month ship reports indicated that the limits of the field ice had retreated rapidly to north of the forty-seventh parallel. After the flat ice was melted by sun, wave, and warmer water the large bergs, being much more resistant, remained to continue their southward drift toward the Gulf Stream waters. The great majority of the April bergs were situated between the 50-fathom curve of the eastern edge of the Grand Banks and a line located 60 miles to the eastward of it. The most southerly bergs of the month were located along the direct southerly extension of this ice stream, where they almost reached to the forty-second degree of north latitude in longitude 49° 30′ W.

There was also a very distinct curving of ice and cold water to the westward around the Tail of the Banks. If this outlet had not existed it is very probable that the southward push of icy waters would have been greater and would have sufficed to carry bergs across the westbound B tracks to the south and southeast of the Tail.

About the middle of the month reports showed that scattered bergs were rapidly advancing southeastward into and across the area of warm surface water to the east and west of 42° 50′ N., 44° 30′ W. One of these bergs actually crossed the westbound B track from Fastnet, in longitude 43° 50′ W. This push of bergs was quite alarming, and was one of the factors that made the patrol recommend a shift of tracks south to the extra southern or "A" lanes on April 19, though, as matters turned out, after that date there were very few further reports of threatening bergs in the eastern part of the ice-patrol area. The warm waters rapidly melted the southeasternmost of the invading bergs and their ranks were not filled by new levies from the continuous procession moving south along the eastern edge. During April, 1928, there was a southeasterly push of bergs very similar to the one of 1929. The feature this year, however, in common with all ice conditions about the Grand Banks from April on, was far heavier and more serious. This year the patrol ships were prevented by the ice just below the Tail from investigating the southeastern sector themselves; therefore a careful study of the subsurface conditions in the latter area could not be carried out. The bergs, as shown

by numerous reports, were apparently drifting southeast across warm water at right angles to the surface isotherms and to the usually conceived direction of the Gulf Stream drift. The 120-mile berg-free separation of the southeasternmost bergs from the ice just below the Tail precludes, when combined with a study of the successive reported positions of the ice, the belief that the former group was made up of bergs that had earlier drifted south past the Tail and got into a northeast-flowing current.

MAY

Early in the month the two latest reports for the year were received of the Gulf of St. Lawrence field ice, both from the northern end of St. Pierre Bank. In the Grand Banks region farther to the eastward great changes took place in the ice situation. Throughout the month the surface waters north of the forty-second parallel remained on the average considerably colder than in 1928. Nevertheless, the effects of the advancing sun caused field ice that drifted south of Newfoundland to melt with considerable rapidity and the southern limits of the pack ice to retreat apace. Before the end of the month field ice was reported for the last time in 1929 from anywhere in the ice-patrol area.

Bergs were present in almost unheard-of numbers northeast of the Grand Banks, especially in the area extending 150 miles northeast from the line between 48° 15′ N., 51° 10′ W., and 45° 50′ N., 47° 10′ W. The patrol vessels, as usual, watched the southernmost ice and in the cases of a few critical bergs were able to determine their drift tracks. These are located in the general vicinity of the Tail and are shown by dotted lines on the ice chart.

During May there was an unexpected falling off in bergs south of the forty-third parallel and a lull in the menace to the United States, Europe tracks. Almost all bergs that reached the latitude of the Tail curved closely around it and passed to the westward. Instead of continuing northwestward along the southwest edge of the Banks, some of this ice, as it had done during April, turned offshore and pushed southward along the fifty-first meridian from the forty-third parallel. However, the southernmost ice of the month, which was along this line, failed to reach even the westbound "B" track to Boston by over 30 miles.

The ice chart for May shows an apparent lack of bergs along the eastern edge of the Banks between 44° 00′ N. and 45° 30′ N. This is probably due to the fact that the area concerned was crossed so little by reporting steamers that many bergs undoubtedly escaped observation there. The shifting north of the Canadian tracks as soon as the ice conditions permit in the spring leaves a wide comparatively unsearched gap between the usual seat of operations of the ice patrol

in the latitude of the Tail and the next set of traffic lanes to the north.

JUNE

The severity of June, 1929, from an ice standpoint, can best be seen when one compares the month's ice map with that for June, 1928. (See United States Coast Guard Bulletin No. 17, fig. 10.) Though the chart for the latter month shows a total number of bergs south of the forty-eighth parallel somewhat in excess of normal, and one berg with an extreme southerly drift, the total number of bergs in the ice-patrol area during June, 1929, was several times as great and the situation was considerably more dangerous.

The surface waters north of the Banks, along the eastern edge, and to the westward of the Tail continued to be abnormally cold. A feature of the month was the recurrence of a great number of bergs south of the Tail. These bergs extended from 43° 10′ N., 53° 00′ W., to 42° 40′ N., 48° 00′ W., and along a 190-nautical-mile front the foremost of them pushed farther south than did any bergs during May.

North of this group, except along the tracks of the few cooperating vessels that crossed the eastern edge, there is a relative scarcity of bergs plotted, but, as stated above in the discussion for May, the lack of bergs plotted in certain areas can often be credited to lack of reporting vessels rather than to actual lack of bergs. In June the Canada-Europe traffic was on the Cape Race tracks, still farther north than it had been during the preceding month. Had the waters along the eastern edge been well covered by the patrol ships or by reporting vessels, doubtless a considerable number of bergs that remained unreported would have been found.

From along the Cape Race, or F tracks, great numbers of bergs were reported. Even there, however, they noticeably thinned out in numbers as the month progressed. During June shore stations located along the Newfoundland coast between Cape Race and St. Johns began to sight bergs for the first time in 1929. This was the result of the bergs in the northern part of the ice-patrol area being located on the average much farther westward in the ocean than earlier in the year. The disappearance of the field ice with the advance of the season is regularly followed by a westward movement of the average of the drift tracks of bergs north of the forty-seventh parallel. A continuation of such a tendency finally results in a failure of supply of bergs to the narrow cold stream that runs south along the eastern edge. It is just as though the supply of grain to the hopper of a mill were cut off by the slow deflection of the grain chute that keeps it filled. Even though the bergs should keep coming down in undiminished numbers across the forty-eighth parallel (which they never do), the farther west they come down in the ocean the less is

their chance of getting south past the islands and rocks of the Labrador and Newfoundland shores and past the shoals and slack waters that exist along the northern edges of the Grand Banks.

JULY

Though still abnormally heavy from an ice standpoint, July, 1929, when compared with the preceding month, shows a great decrease of bergs along the Cape Race tracks. The ice extended a little farther to the westward around Cape Race than in June, but it did not drift through the gulley off this point beyond longitude 53° 10′ W. Many ships went east and west past Cape Race, and if any bergs had been located farther to the westward they would certainly have been reported.

The few bergs reported from unusual positions near 45° 00′ N., 54° 30′ W., and 43° 00′ N., 53° 00′ W., were doubtless straggling remnants of the ice that had made its way so freely to the westward around the Tail during the previous month. The westward tendency in the southern part of the ice-patrol area was definitely stopped early in July by the pushing northeast to the Tail of an undulation in the northern limits of the Gulf Stream. This invasion of warm surface water almost entirely obliterated the extension of cold current that had previously passed westward around the Tail. At the same time it caused the southern branch of the Labrador Current to increase in power and extension until it was carrying bergs southeast almost to 41° N. 48° W. The United States-Europe ships had been recalled from the extra southern A tracks, and such an unlooked-for final push of ice and cold water caused the patrol deep concern. From the 11th to the 24th it sent a number of large bergs drifting eastward right along the path of the liners on the westbound B tracks.

During the last few days of the month the southernmost bergs melted under the eyes of the patrol. Their final disintegration was quite rapid because of midsummer air and water temperatures and apparent mixture of the surrounding northern waters with the Gulf Stream drift. As the southern limit of the ice gradually retreated northward the patrol followed it along from berg to berg, for the push of the cold waters had weakened and no new ice was coming down to take the place of that melting below the Tail. The exact status of affairs a little to the northward along the eastern edge could not be determined during the closing days of the month because persistent fog remained over the narrow stream of pure Labrador Current water that according to surface temperatures, still extended to just south of the forty-third parallel.

AUGUST

The long, heavy ice season finally ended during this month. August saw but one report of ice from the ice-patrol area proper, that of a berg on the 3d near the Newfoundland coast just north of St. John's.

There were reports of five bergs early in the month from north of the Banks, but none of these were ever reported from south of the forty-eighth parallel. Constant fog prevailed over the narrow cold stream of cold water along the eastern edge of the Banks until after the ice-patrol service for 1929 was discontinued on the 3d, so it is just possible that an unreported berg or two may have disintegrated there unseen.

SEPTEMBER

A berg was reported on the 19th from 44° 05′ N., 44° 30′ W.

GENERAL REMARKS AND SUMMARY

The above monthly discussions and the charts following this section show in general how ice was distributed southeast of Newfoundland throughout the 1929 ice season. A narrative account of the ice seen from the patrol vessels, together with remarks on circumstances attending its disintegration in some instances, can be found, respectively, in the sections devoted to the cruise reports and oceanography.

The following tabular summary shows how the 1929 monthly berg totals compare with those of the average year, the latter being based on a study of iceberg reports from south of the forty-eighth parallel for the period 1900–1926:

Month	Bergs south of 48° N. in 1929	Bergs south of 43° N. in 1929	Bergs south of 48° N. normally	Bergs south of 43° N. normally
January	0	0	3	0
February	0	0	10	1
March	45	0	36	4
April	332	32	83	9
May	460	9	130	18
June	376	72	68	13
July	107	21	25	3
August	1	0	13	2
September	1	0	9	1
Total	1, 322	134	377	51

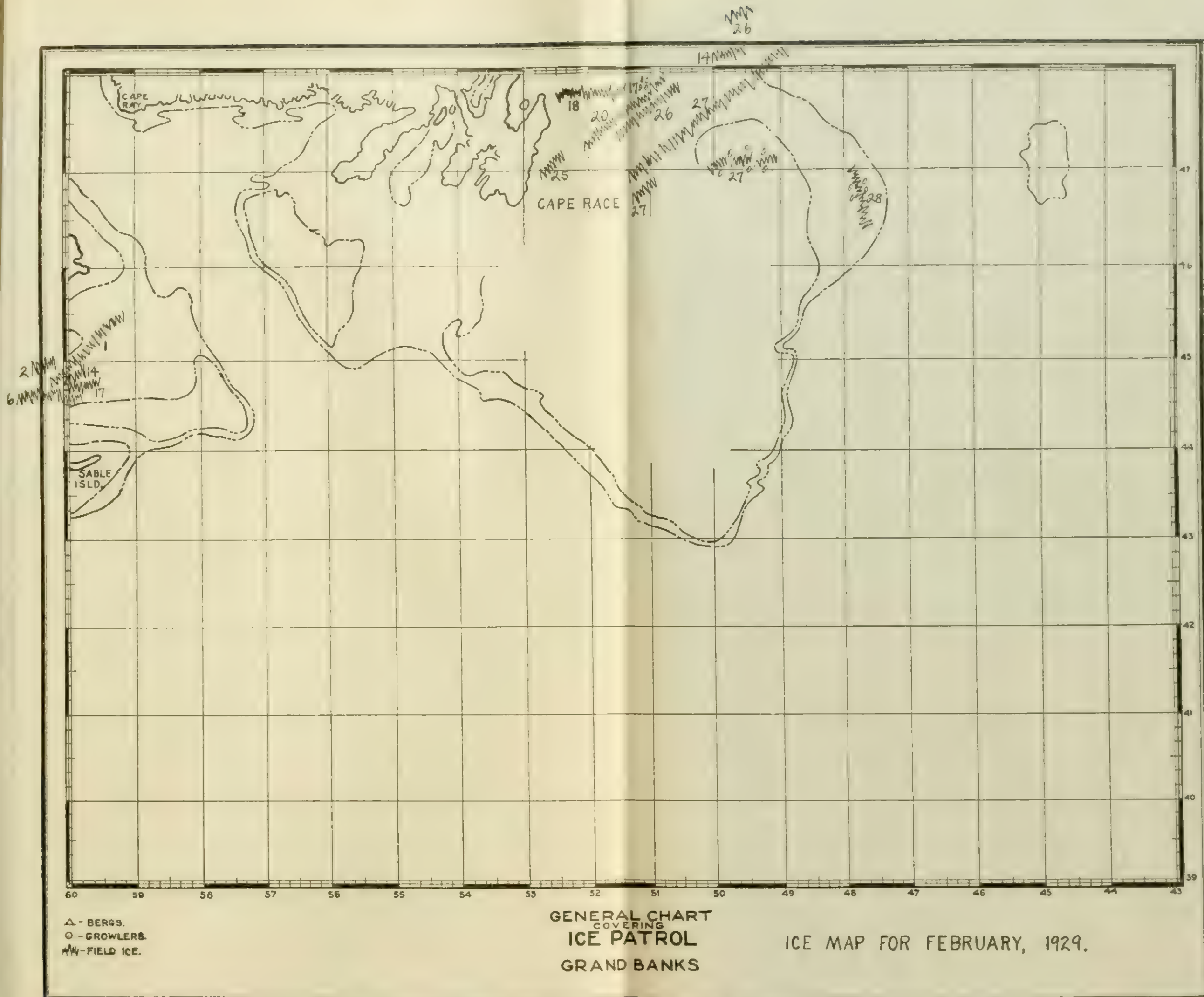


FIGURE 6.—February ice map. No known icebergs were south of the 48th parallel during the month

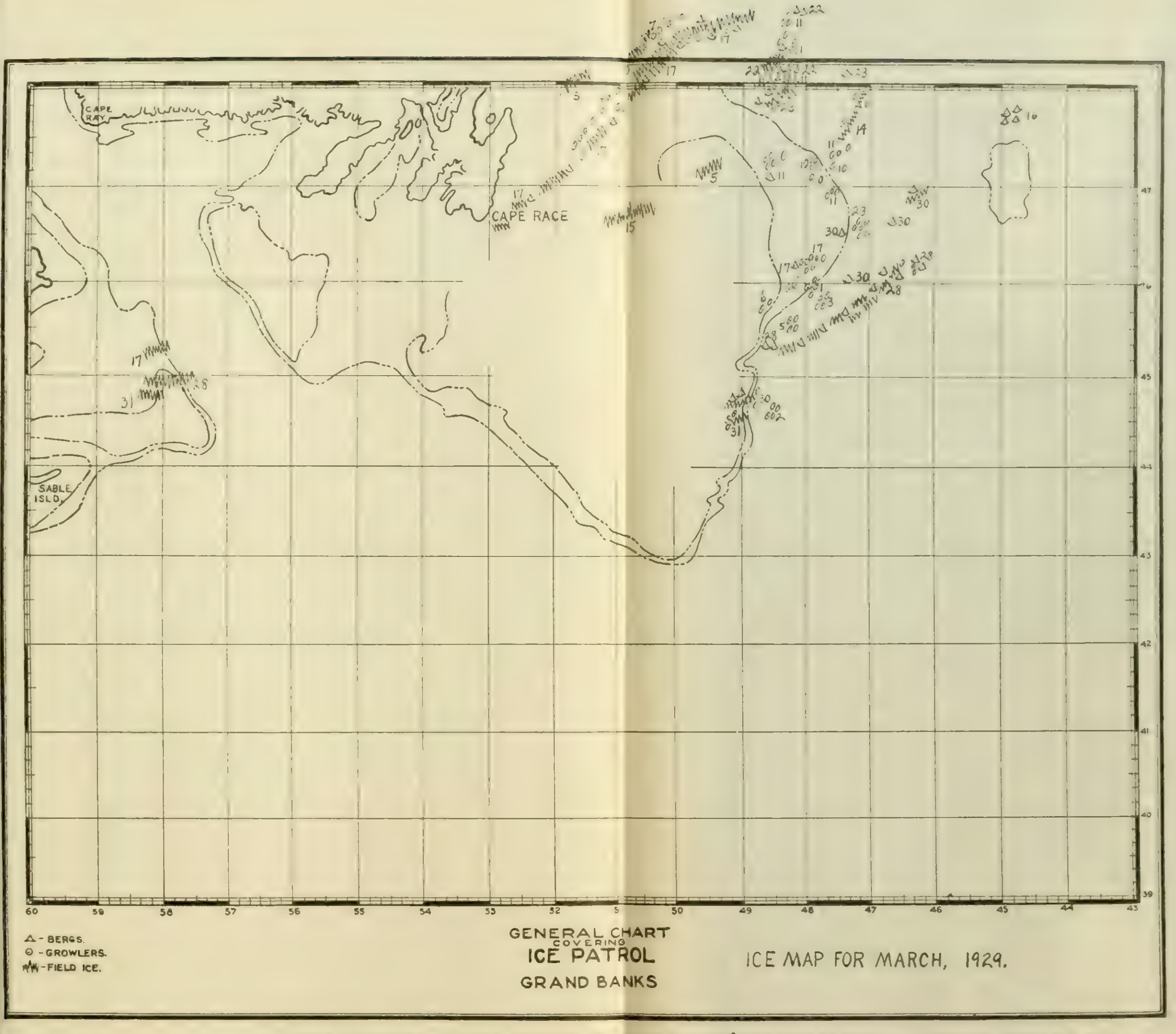


FIGURE 7.—March ice map. Forty-five known icebergs were south of the 48th parallel during the month

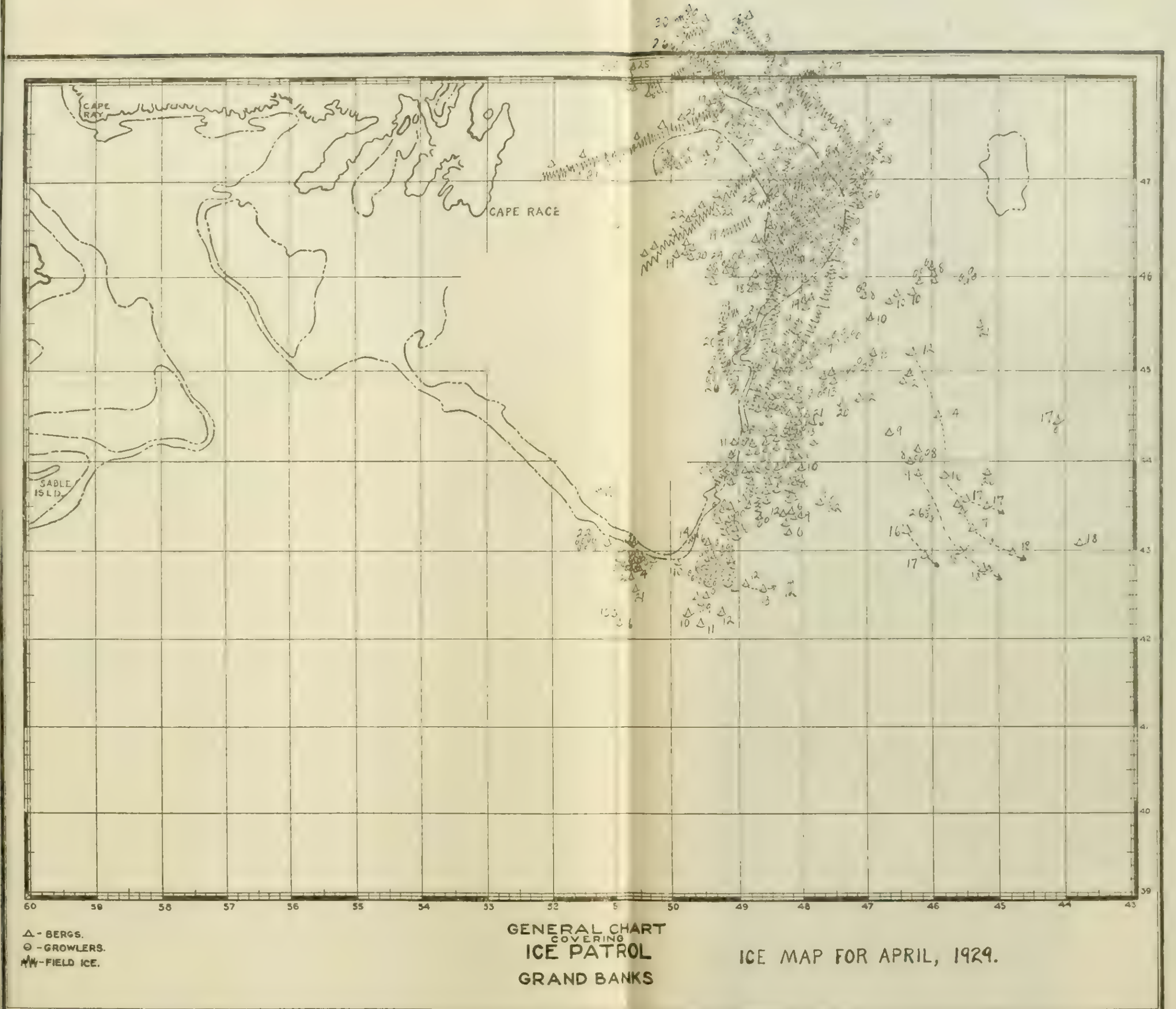


FIGURE 8.- April ice map. Three hundred and thirty-two known icebergs were south of the 48th parallel during the month

100277—30. (Face p. 82) No. 5

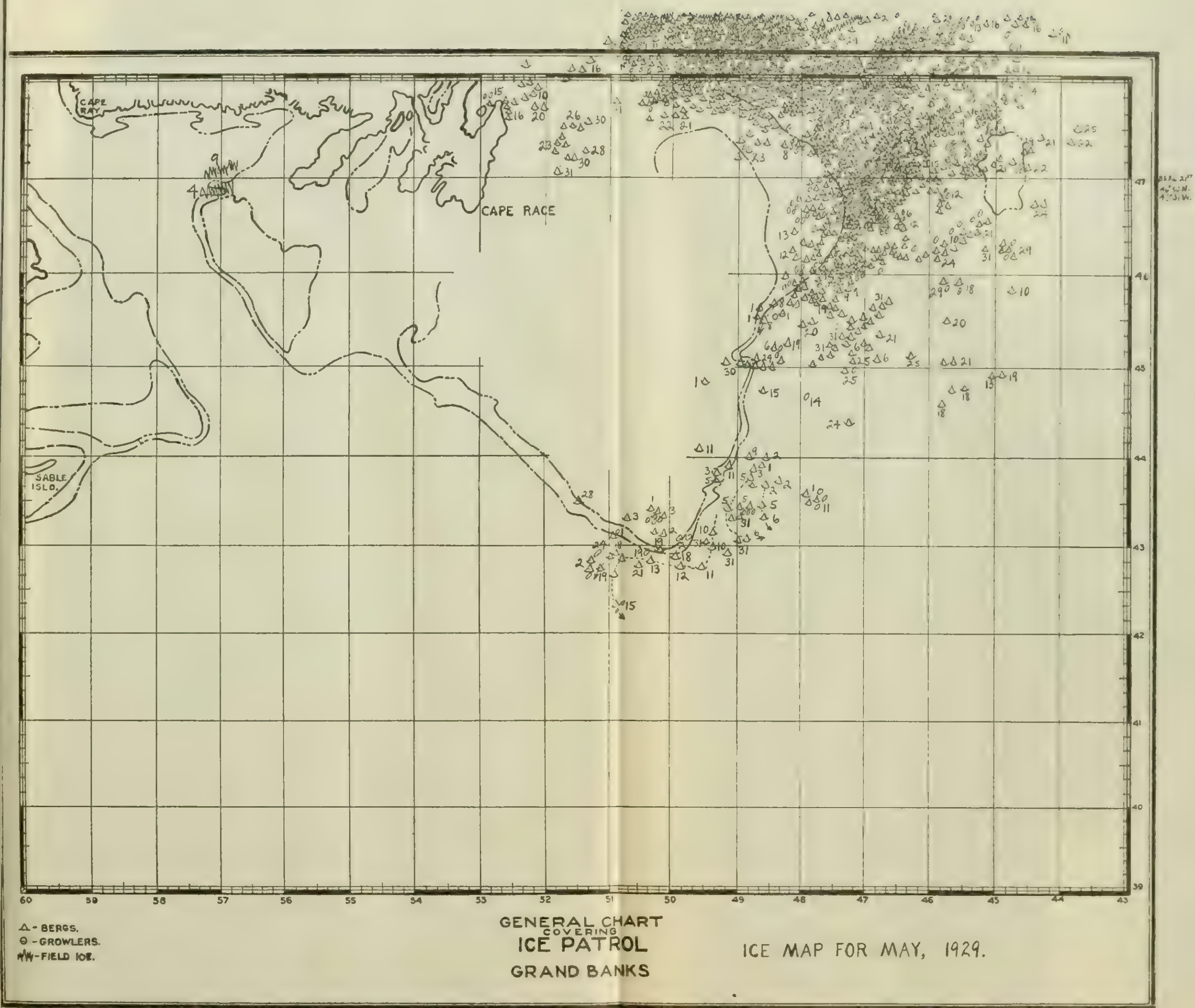


FIGURE 9.—May ice map. Four hundred and sixty known icebergs were south of the 48th parallel during the month.

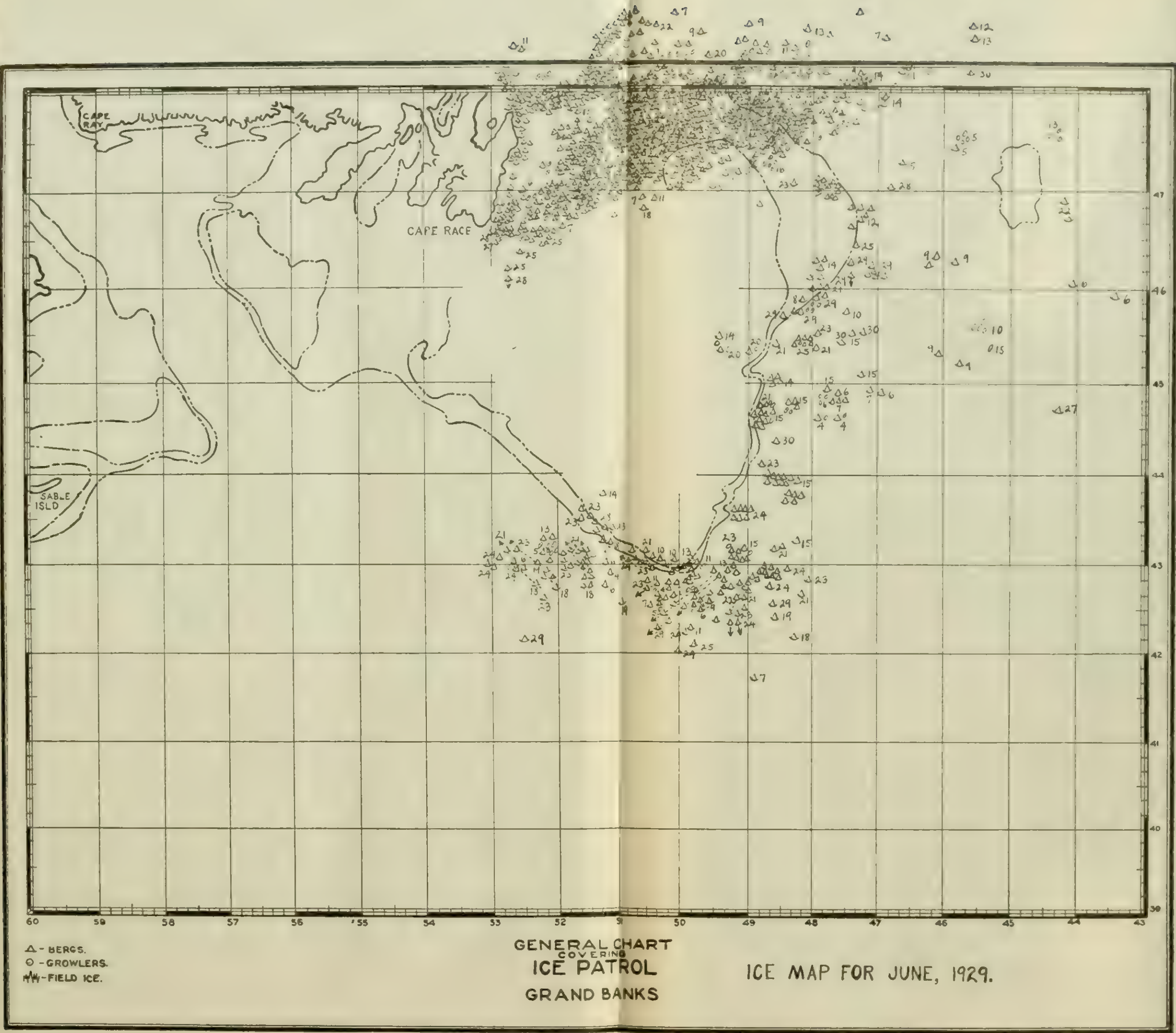


FIGURE 10.—June ice map. Three hundred and seventy-six known icebergs were south of the 48th parallel during the month

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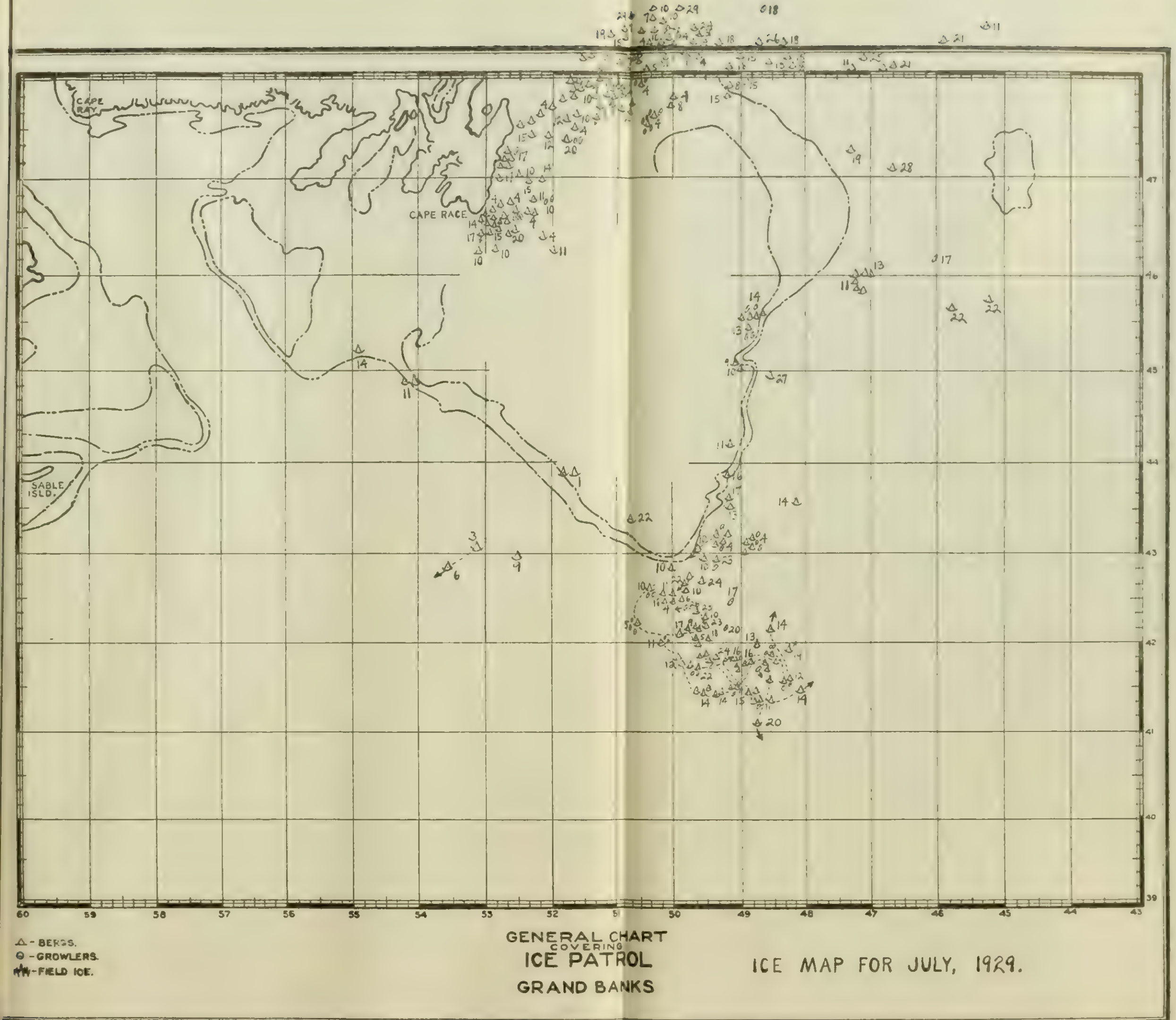

FIGURE 11.—July ice map. About 100 known icebergs were south of the 48th parallel during the month

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SOME OF THE ICE PATROL'S PROBLEMS, AND HOW IT ATTACKS THEM

The primary duty of the ice patrol is locating and broadcasting the position of all ice near the steamship tracks which cross the North Atlantic south of Newfoundland. The patrol service is maintained to assure, if possible, that vessels using these tracks will not run unwarned into ice-infested waters.

The patrol's responsibility is certainly not the safe passage of persons, vessels, and freight across the ice-patrol regions. That is, indeed, the final aim of the ice patrol's work, but the safety of each individual ship is something not under the control of the ice-patrol officials. Safety from dangers incident to collision with ice is dependent upon the judgment of the individual shipmasters in estimating the situation ahead of them. The patrol's broadcasts give these men a certain amount of late information, which is undoubtedly useful as a guide for shaping their course and speed policies past the Grand Banks.

One patrol vessel is out on duty at all times during the heavy ice season. The fuel capacity and other limitations of the vessels that have been used to date are such that they can cruise at about 10 knots during daylight hours of good visibility during their 15-day duty periods in the ice regions, and ordinarily no more. Greater work than that they can not do because of the need for fuel to carry the ships to and from the ice area, to evaporate sea water for domestic and boiler purposes, to supply demands for steam during long stand-by periods of fog, darkness, and storm, to retain position in currents, and for emergency reserves.

Bad visibility and bad weather together are so prevalent that on the average the patrol can count on no more than 150 hours of efficient searching weather per 15-day period of patrol duty. During these 150 hours the patrol ship averaging 10 knots can run 1,500 sea miles and can sight bergs at an average distance of not over 15 miles on either hand. In other words, the patrol vessel herself can examine not over 45,000 square sea miles of water area per average patrol cruise, even when every available hour of good visibility is utilized to the full for search purposes.

Some ground is lost because of doubly searched areas that unavoidably exist about the corners of the search patterns. Other reasons, such as necessary overlapping of searches made on different days due

to indeterminate differential surface drifts of neighboring sea areas, and large ship drifts during periods of darkness and low visibility, cause additional losses. As a matter of fact, a good figure to take for the maximum actual area that can be well covered for ice by one patrol ship per 15-day patrol cruise is 30,000 square sea miles.

The area about the Grand Banks that most frequently contains bergs and to which it is desirable to confine most of the patrol's activity lies between longitudes 43° and 54° W. and latitudes 40° 30′ and 48° N. Deducting the area of the Avalon Peninsula of Newfoundland and that of a warm iceless portion in the southeastern corner of this region, it will be found that the total area south of the forty-eighth parallel which is most likely to contain ice contains about 168,000 square geographical miles. Some of the areas over the Grand Banks themselves are not frequented by trans-atlantic traffic. There is, besides, very little sustained current in the shoal water. Therefore, the total area which must be most closely watched can be reduced to about 150,000 square geographical miles.

North of this great southern ice area and extending eastward for several degrees of longitude from the North American coasts, the waters are particularly liable to be congested with ice. It is normal for unnavigable field ice to exist over broad areas immediately north of the forty-eighth parallel during several winter and spring months. The same waters are liable to be more or less thickly strewn with bergs throughout the whole year. Though ice conditions vary in different localities for various reasons, it is true, generally speaking, that the farther north of the forty-eighth parallel one goes along the North American coast the worse will be the ice conditions met. This holds true all the way up into the Arctic regions that are choked all year round with impenetrable field ice.

The serious ice conditions likely to be met at any time to the north of the Grand Banks and the forty-eighth parallel are doubtless well realized by the masters of all vessels crossing in the higher latitudes, so for all practical purposes this area can be considered as beyond the ice patrol's particular sphere of action, though not at all beyond its sphere of experience, interest, or knowledge. Ice information received in the form of reports from the northern sections is always placed in the broadcasts and retained for about five days before being dropped. Any vessel requesting special information from the patrol ship regarding ice in the area north of the forty-eighth parallel will usually be able to get valuable information.

There have been occasional reports of bergs to the west, south, and east of the usual ice area between 43° W. to 54° W. and 40° 30′ N. to 48° N. Ice in such locations, however, may be considered as due to extraordinary berg or current conditions. The ice-patrol ships themselves can not attempt to locate ice in waters where it is

only phenomenally present any more than they can keep track of all the ice in the tremendous ice regions of the north. As a matter of fact, if the patrol limits its cruising activities to the important ice area of 150,000 square sea miles about the Grand Banks, it is confronted with a very sizable problem, for it has been shown that in a full 15-day cruise period the patrol's own searching can be made to cover but about one-fifth of such an area.

The result is that the patrol is compelled to concentrate on the most critical parts of the 150,000 square sea mile ice area south of the forty-eighth parallel. It relies upon reports from passing ships for its knowledge of ice in many parts of this area, as well as in the surrounding northern and southern regions, that on the one hand always, and on the other only exceptionally, contain ice.

It may be of interest to state here what takes place on the patrol vessel when ice or water temperature reports are received. Copies of all these incoming messages are promptly taken to the chart room and delivered to the ice-observation force. They first scrutinize the reports for errors. The tracks and approximate positions of all regularly reporting steamers while in the ice-patrol area are kept plotted on special charts. If a new report is from an obviously improbable location, some distance from where the reporting ship should have been at the time of origin of the message, the value is thrown out if an ordinary temperature report. If it is an ice report, or a water temperature value from an area that few vessels have been through recently, an inquiry for verification of the questionable location or other particular is promptly sent out.

At this point it should be noted that the size of bergs seen at sea at a distance of 2 or more miles is very deceptive. There is usually nothing of known size near them with which they can be compared. The patrol itself has frequently seen bergs that appeared to all on the bridge to be very large pinnacled ice masses when they were near the horizon, but which, when closely approached, proved to be rather insignificant, rising less than 30 feet above the sea and being less than 100 feet in diameter. So it is that bergs in the frequently bright smooth waters of the southern ice sectors, though reported as "large" and "very large," are often found when reached to be in fact quite small. They were probably sighted on the horizon line when nearly abeam of the reporting vessel, which had never closely approached and examined them because of the loss of valuable time that this would have involved.

The unusually large refraction values often found near the junction of the warm and cold waters makes the identification of bergs difficult and adds to the uncertainty when determining berg sizes from a distance. Sometimes bergs not over 30 feet high can be seen for 20 to 30 sea miles from a height of eye of 20 feet. Once during the 1929

ice season on a day when refraction was making objects loom up higher than usual the white ice-patrol vessel was reported to herself as a berg by a steamer that was observed to be passing by at a distance of approximately 10 miles.

However, if after a careful inspection no flaw in an incoming iceberg or temperature report is apparent, it must be accepted as correct and plotted on the cruise chart. The plotted bergs always have the date of the report written near by so that their successive positions from day to day can be followed. The water temperature values are plotted in different colored inks, the colors being changed every few days to enable the special portion of the cruise period during which they were received to be readily seen.

The water-temperature values and the ice, but especially the latter, are never looked upon as something fixed and unmoving. They are constantly regarded as though in motion, and from the moment they are plotted they are looked at with a continually questioning attitude. Where will they be and how much will they be changed in one, two, or more days? If the patrol is to be of high value to shipping this attitude is necessary. Bergs often have to be found several days after they have been reported, as at the end of a period of fog, or after the patrol has been released by the complete melting of a particularly dangerous berg that was being watched. Constant estimates must be made of berg positions at the expiration of different time intervals. The patrol has time to search out only the most probable locations of reported bergs. In most cases, due to the normal prevalence of strong currents, it can afford to go directly toward the spot where a berg was last sighted or reported only when the information is extremely recent, say, less than one day old.

The task of keeping track of the southern ice limits would be fairly simple if good visibility were as prevalent over the Labrador Current as it is over the Gulf Stream 180 miles south of the Tail of the Banks. As it is, the patrol has to keep up a constant matching of its wits against fog-shrouded currents. Its errors and successes are strongly brought home as its searches during daylight periods of good visibility are successful or fruitless. There is a constant stimulus to find new ways of predicting berg movements and to perfect the old, not so much for the information of shipping, but for the guidance of the ice searches of the patrol vessels themselves.

As the bergs are little affected by the wind, their movements are mostly controlled by ocean currents. Therefore, any method of predicting ice movements entails finding out the drift of water at the time. The present state of knowledge regarding ocean physics about the Grand Banks makes it appear that hydrodynamic surveys are the best means for determining the oceanic circulation there. The ice patrol has studied and worked with dynamic oceanographic

methods for some years. It has been found that the making of satisfactory surveys of this sort entails steaming over large areas frequently, for the precise surface and subsurface information that must be obtained can only be gathered by the patrol vessels themselves. With only one ice patrol vessel out on duty at one time this interferes greatly with the normal conduct of the practical part of the service.

The second-best method of determining currents and berg drifts about the Grand Banks is the interpreting of surface isotherm curves in the light of past experience. The cooperation from shipping that has been worked up enables the patrol vessel to plot the surface isotherms over a large area. The requirements of the hydrodynamic method and the dependence which can be placed on the surface isotherms are both discussed in the next chapter.

Conditions under which the patrol vessels work vary from month to month and from year to year. Weather conditions and information about ice coming in by radio often make it wise for the patrol to alter its course of action several times during even a single day. No hard-and-fast rules can ever be laid down, but existing circumstances, as viewed in the light of the patrol's past experience, must always determine the cruising and other activities of the patrol vessels on each cruise. As a general principle, however, it can be said that the patrol must leave for other vessels to find and report all ice east of the forty-seventh meridian and north of the forty-fourth parallel. To narrow down and simplify the problem still further, it can be stated that the patrol vessels should almost exclusively confine their own activities to the area of an equilateral triangle with sides about 175 sea miles long and corners near 41° 30′ N., 47° 00′ W., 41° 30′ N., 51° 00′ W., and 44° 48′ N., 48° 00′ W.

The above triangle contains about 13,200 square sea miles, and so is of the order of size that theoretically can be searched for ice two times during each patrol cruise. The areas along the western and southern edges of this triangle are most critical and should never be left unguarded for more than a very few days at a time, even during light ice periods. The reason for this is because the general drift of ice is southward down the western part of the triangle, then eastward along the westbound B steamship tracks near the southern part of it, and, finally, northward and northeastward away from the southern tracks and across the eastern side of the triangle.

A berg entering the circulation at the northern apex of the critical triangle, if it is not melted, shunted off by local currents, or held up by some means such as grounding or coming into an eddy, can easily be discharged into a very dangerous position right along the westbound B tracks within a period of from 10 to 15 days. Fog and strong currents and the necessity for standing by the most dangerous bergs, whether they are inside or outside of the critical triangle, make the

actual proper patroling of even the critical western and southern parts of its 13,200 square sea miles a continual problem.

During heavy ice periods about the only times when the area inside of this triangle should be left are when bergs that must be followed drift west or south of its southern portion. Of course during very light-ice times, which occur near the ends of some seasons, it sometimes happens that there is no ice in the critical triangle. Then occasional runs to the north can be made in order to locate the southernmost ice limits. Generally speaking, however, throughout the active ice-patrol season, if a high degree of safety from danger of collision with ice is to be maintained during times of low visibility along the B tracks, the western and southern portions of the critical triangle must be constantly and repeatedly searched. The ice found there must be most carefully watched and followed until it either melts or recurves and drifts so far to the north that it no longer menaces the B tracks.

During most of the ice-patrol season the B tracks just south of the critical triangle are in constant use. That means the route of westbound traffic to the United States lies right along the southern edge of the critical triangle. These westbound ships are of great assistance in reporting water temperatures and in notifying the patrol of chance bergs that may be crossing the southern part of the triangle for points farther south, with some drift of cold water. The eastbound B tracks are 60 geographical miles south of the westbound ones, and so are considerably safer than the latter, on the general proposition that the farther south of the Tail of the Banks one is in the ocean, in the long run, the fewer bergs will be encountered. The eastbound traffic is doubly protected from liability of meeting unreported ice by the active operations of the westbound ships in cooperating with the patrol.

Nevertheless, the 60 miles separating the eastbound and westbound traffic streams of the B tracks can be traversed by a berg during certain times of accelerated circulation in a period of about 30 hours. Therefore, especially toward the ends of periods of fog of two or more days' duration, even along the eastbound B tracks, vessels while between 52° W. and 45° W. are subject to a real, though very slight, chance of unexpectedly meeting an unreported iceberg. Because of the much greater danger along the westbound B tracks, however, the ice patrol must at all times exert its utmost efforts to locate all bergs that are approaching the latter lanes from the north.

Freighters, tankers, and other vessels not carrying passengers are not included in any track agreement and are not expected to adhere to any definite lane. A large number of the bolder vessels of the non-passenger class cross the ocean about where they see fit. The reports from such sources are the main dependence of the patrol for its knowl-

edge of by far the largest part of the great area lying between the United States and the Canadian tracks. This area is large when the patrol season starts, but it becomes very much larger as the advance of the spring melts back the field ice and permits the Canadian tracks to be shifted farther and farther north. It goes without saying that the value to the patrol of temperature and ice reports from vessels crossing between the usual tracks is inestimable. A large gain would be effected by the ice-patrol service if all such vessels would report their positions and water temperatures regularly instead of remaining silent unless they see ice, as it appears a number of them still do.

Those passenger vessels which cut to the north of the tracks that are in effect (and the patrol noted, in 1929, 100 different cases where vessels carrying passengers were 20 miles or more north of their prescribed lanes), if they do not take rigid extra precautions, decrease their chances of coming through the ice regions safely. Their masters should bear in mind the fact that the ice-patrol broadcasts do not necessarily list all the icebergs in any area, but only the icebergs of which the patrol and the reporting vessels have knowledge. The positions of ice in the broadcasts are always subject to a certain amount of observational error in the first place, and they become less and less reliable as time goes on, due to the impossibility of accurately forecasting berg drifts. Hope to make absolute determinations of future berg drifts can be expected neither from construction of dynamic current maps nor isotherm and ice charts. The best that can ever be hoped for is some reasonable approximation of the most probable courses and rates of movement that given bergs will take.

South of the Tail of the Banks reported positions of bergs, even if correct within a mile to begin with, are normally subject to a 24-sea-mile radius of error with every day that passes from the time of the last report of them. Occasionally swift currents cause the radius of error to reach 48 sea miles daily, and very exceptionally to approach 72 sea miles per day. The dates given with the positions of the southernmost bergs enable the recipients of the broadcasts to determine within 24 hours the time the different bergs were last reported or sighted. This permits their making a very rough approximation of probable berg locations when knowledge of the usual drifts of ice is at hand.

Some passenger liners, both eastbound and westbound, maintain notoriously high rates of speed, such as 20 knots, more or less, according to ability, even during periods of fog and darkness. The ice patrol has noted that a few of them actually maintain such speeds during bad visibility conditions when they are 100 miles and more north of their proper tracks. Such action is extremely foolhardy and is bound to result sooner or later in disaster.

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Vessels maintaining high speeds southeast of the Grand Banks, as well as in more northern parts of the ice-patrol area, are at times dependent for safety on their chances of having an ice-free track ahead of them. It is entirely idle to think that microthermographs, subsurface echo or listening devices, or any other instruments that have as yet been developed by science, can protect ships from collision with ice if they are traveling at from 10 to 24 knots during dense fog, pitch darkness, and the like. If any device for detecting the presence ahead of bergs or heavy field ice were practical the fine steamers on the Canadian tracks would adopt it and proceed at reasonable speeds during bad conditions of visibility instead of stopping or groping along at about 3 knots, as many of them do at such times, while between the longitudes where icebergs are situated.

The danger of collision with ice is a real and not a fancied one at many times and places south of the Cape Race tracks and even south of the Tail. The *Titanic* is far from being the only vessel to have struck a berg. To mention two recent cases, the reader is reminded of the *Montrose*, which in 1928 and the *Vimeita*, which in 1929, struck bergs head on off the eastern edge of the Grand Banks. Neither vessel was lost, but heavy damage was sustained in both cases. No one should deceive himself in this matter. To depend blindly on the broadcasts of the ice patrol is not enough. The only way to be sure of not hitting ice in regions where bergs are liable to exist is to keep a bright lookout and to travel at speeds low enough to insure ability to stop or turn aside before striking a berg just visible ahead under the prevailing atmospheric conditions.

The Western North Atlantic can be likened to a great dance hall and the bergs to dancers. The southern part of the room is warm and unoccupied. The cold northern part of it is where the orchestra of the wind holds sway. There the floor is crowded by jostling dancers through whom one must pick one's way with great care. The central part of the room is occupied at times by a few of the hardiest and swiftest performers. Their maneuvers are watched, but the floor is vast and the light is so bad that fully half the time they can not be seen. Sending vessels past the Tail at high speeds during low visibility is like rolling thin glass balls across the central part of such a dance floor and hoping that they will not strike the flying feet of the dancers that occasionally execute intricate figures in the middle of the hall.

For postulated berg sizes and frequencies the mathematical chances of collision with ice under the worst conditions of high speed and low visibility can easily be calculated. Let us suppose that bergs 300 feet in diameter are ahead of a fast liner and that there is only one such berg along each 60 mile front at right angles to the course line. It very frequently happens that the southernmost bergs have not been

sighted for 24 hours because of fog. A berg may move north, though the flow of the main body of the Labrador Current more often makes it move south. If it goes south very rapidly under the above conditions of berg distribution the chances are good that the next berg to the north will take its place in the 60 mile section immediately ahead of the ship. In 24 hours the position of each berg south of the Tail may be assumed to be indeterminate by about 30 sea miles. What is the chance that ice will be hit?

The breadth of the liner can be neglected, for her maneuvering powers may be such that she can avoid a berg sighted ahead by half the amount of her beam, though if not properly made use of these same maneuvering powers are capable of causing a long raking collision when otherwise the vessel would have just passed clear. The chance that a berg will be hit works out at 1 chance in 1,200, the ratio between the 300-foot diameter of the bergs and the 60-mile front at right angles to the course line along which each berg was assumed to lie.

Such chances are not desperate ones, and they would doubtless be welcomed by trans-Atlantic fliers; but the aspect becomes different when it is considered that there are exceedingly many steamship crossings past the Tail during fog and darkness each season and that when bergs are far south they are likely to be spaced much closer than one to every 60 sea miles at right angles to the track.

Frequent long periods of fog make it impossible to guarantee that occasionally unannounced bergs will not get upon the B tracks. Whether or not there will be disastrous collisions with ice in the North Atlantic depends largely on the speed at which vessels run during thick weather and darkness while they are east, south, and southwest of the Tail. Ships crossing north of the Tail are, as has already been said, liable to meet more and more icebergs in proportion as they cross the Labrador Current in higher and higher latitudes; but their masters realize this and generally run very slowly during low visibility, thereby minimizing the chances of serious damage in the cases where they find collision with ice is unavoidable.

The above all serves to place some of the problems of the patrol before the reader and shows the inherent danger that lies in neglecting the scouting program for any purpose at all, even that of attempting to make current maps by the hydrodynamic method. So long as there is only one vessel out on patrol at a time, oceanographic stations can be taken here and there without any appreciable interference with the practical program, and this should certainly be done to keep up the annual continuity of the records of salinity and temperature offshore about the Grand Banks. Much useful information and much training in physical oceanography that may be valuable in the future, is given by the occasional scattered stations; but such station

arrangement only gives fragmentary dynamic information, and most assuredly does not permit the making of current maps of a sort that can be used as the basis for confident prediction of berg drifts.

The Convention for the Safety of Life at Sea that was held in London in 1929 took up the matter of the ice patrol and recommended that a maximum of three instead of two ships be made available for the work. It is hoped that in the future it will be possible to employ a third vessel whose complement will include a professional oceanographer. The ice-scouting and information-broadcasting vessels could then be relieved of the burden of the larger part, at least, of the scientific oceanographic work.

The addition of a vessel primarily for the scientific program would mean a great step forward and would be justified even if the dynamic current maps which it could make should finally prove to be of small practical value. In addition to the large funds of knowledge that such a ship should be able to obtain for pure science in such fields as oceanic circulation and submarine bottom configuration, her presence about the Grand Banks under the direction of the commander, International Ice Patrol, would at critical times be of great practical value. She could send in surface temperature and weather conditions reports to the scouting ship from areas from which no ships were reporting and could be called upon when necessity arose to search key areas or to trail and observe the final disintegration of especially dangerous bergs.

The main patrol vessels, on the other hand, when relieved of the oceanographic station work could better take on board the necessary additional personnel and gear to permit a start to be made in the matter of ice scouting by aircraft from the patrol vessels. The cautious and well-thought-out use of aircraft to assist during periods of fine weather in searching out the region in and near the critical triangular area just north of the B tracks would seem to be one of the most promising of the fields of development that are open to the ice patrol at the present time.

OCEANOGRAPHY

1. Scientific work during the 1929 patrol season.
2. Prediction of iceberg drifts.
   A. Surface isotherms as basis for prediction.
   B. Dynamic current maps as basis for prediction.
3. Estimate of total annual amount of glacial ice south of forty-eighth parallel and its total chilling effect on the water.
4. Observations on iceberg disintegration south of the forty-fourth parallel.
5. Possibility of breaking up icebergs artificially.
6. Local convectional circulation about icebergs.
7. Miscellaneous.

1. SCIENTIFIC WORK DURING THE 1929 PATROL SEASON

Following immediately after this chapter the reader will find figures showing a number of current diagrams and oceanographic sections constructed from data obtained at some of the 69 oceanographic stations occupied during the season. That portion of the year's stations too isolated either in time or place to be utilized for the construction of current diagrams or sections are of scientific interest as records of 1929 surface and subsurface temperatures and salinities in the vicinity of the Tail of the Grand Banks. Therefore, all station data are given in full at the end of this pamphlet.

Station procedure in general and the normal levels to be sampled were the same in 1929 as since 1925. The main advantage in adhering to the same levels year after year is that the values found are then strictly and easily comparable over long periods of time. Uncorrected Richter and Wiese reversing thermometers without attached auxiliary thermometers were used in Greene-Bigelow water bottles at all stations. The variable-speed electric hoists used at the stations were equipped with spooling devices that laid up the $\frac{5}{32}$-inch steel wire on the drums satisfactorily. The hoists gave good service without any interruptions and there was no loss of gear.

One of the ice patrol's two electrical salinity determining cabinets having worn out, the use of a titrating outfit for the *Modoc* was obtained through the courtesy of Harvard University. This method of determining salinities, new for the ice patrol, was purposely set up and tried out during rough weather early in the season. It was found perfectly workable when due precautions were taken to handle the delicate glass instruments with care and to protect them by the use of suitable racks and string ties.

The electrical salinity measuring method as used on the ice-patrol vessels is about twice as fast as the titration method and is much easier and simpler; hence it should be used when a very large number

of water samples are to be handled. The comparative cheapness, light weight, and availability of the titrating outfits, however, make them preferable to the electric-salinity cabinets, unless over 1,000 samples of water are to be analyzed per ship per season. The former are from twenty-five to fifty times cheaper and lighter than the electrical outfits. For worth-while results both methods require well-trained and conscientious operators. Under comparable conditions the accuracies obtainable by the two methods are probably about equal.

The large number of bergs south of the forty-eighth parallel during the 1929 ice season claimed the patrol's almost undivided attention. If the ice had been less, either in extent or amount, more oceanographic work would have been done. In a general way, and as in previous years, the currents that the dynamic oceanographic computations showed theoretically should exist, actually did exist in fact, as shown by occasional iceberg and patrol-ship drifts.

2. POSSIBILITY OF PREDICTING ICEBERG DRIFTS

A. SURFACE ISOTHERMS AS BASIS FOR PREDICTION

Berg-drift predictions are highly necessary for the information and guidance of the patrol itself, even though the conclusions should not be accurate enough to send out in the broadcasts. Therefore, any method simpler than the dynamic one that the patrol ships could employ without interfering too much with their primary scouting and trailing duties is much to be desired. Having explained at some length in the preceding chapter the features of some of the problems confronting the ice patrol, the matter of predicting berg drifts can now be taken up with clearer understanding.

The only other method besides dynamic mapping that has been suggested for picturing the varying circulation in the ice-patrol area has been that based on a study of surface isotherm charts. The surface isotherms have always been assumed to give a broad general idea of the prevailing water and ice movements in and about the Labrador Current throughout the season. The main reason why the patrol vessel carefully plots both her own surface-temperature observations and those coming in from other ships is because the ice in general is expected to be found and to remain where the water is coldest.

The cruise isotherm charts have been considered valuable enough to reproduce each year in the ice patrol's bulletins, but they have not been given important consideration when attempting to forecast movements of bergs that have not been sighted or reported for some time. The reason for this lack of confidence lies in the numerous discrepancies that have been noted when bergs did not move parallel to the isotherms or even close to the direction which the surface isotherms seemed to indicate they should take.

It is obvious that if it were possible to deduce from a study of the surface temperatures alone the circulation existing at the time, and that is likely to continue to exist for some time to come, the making of estimations of future berg drifts would be rather simple. Experience shows that with the cooperation of passing vessels isotherm charts can be constructed every 15 days which show in excellent detail the picture of surface temperatures over almost the whole of the region between the thirty-ninth and forty-ninth parallels and the forty-third and fifth-sixth meridians. This embraces all of the usual ice regions south of Newfoundland and a goodly area of their surrounding waters as well. It covers an area between ten and twenty times as large as that which two ships of the character of the present ice-patrol vessels could keep properly mapped dynamically in the eddying waters about the Grand Banks, even if they devoted alternating at-sea periods entirely to oceanography.

The making of the isotherm charts from the ship's log and from the received radiograms is a routine process that requires but one or two hours of work per day from two men. It does not consume any of the ship's scouting time or interfere with any other of her ice-patrol duties, and so is entirely within the capabilities of the present ice patrol. On the other hand, the full projection of dynamic current maps is not, as will be shown in the next section.

The vital question is whether the best surface isotherm charts procurable can be interpreted in any way to be relied upon to properly picture the circulation of the layers of water which control the movements of the bergs. Hardly less important is another query: If the true circulation at the instant is mirrored properly, how much can the surface isotherms be depended upon to tell the story of what currents will prevail from two to seven days later?

The first thing that must be done when approaching the problem is to determine what paths icebergs have taken in the past. The main courses that they are likely to follow in the southern part of the Labrador Current are very clearly shown in Figure 30 on page 69 of Coast Guard Bulletin 16. This chart, which sums up the berg-drift information gathered by the ice patrol up to and through the 1927 season, is one of the fundamental sources of practical ice-drift information. It is constantly referred to when bergs are reported or sighted because it gives some information of the direction in which the ice may drift while not under surveillance. This chart and its companion chart, Figure 29 on the page facing it, when compared with the composite picture obtained from a study of all the isotherm charts explain why it has been assumed that the bergs tend to remain in the colder waters and to follow in general the usual paths taken by the varying pushes of the same.

Even when the case is narrowed down from full seasons and cruise periods to that of individual drifts it is still found that a good agreement is actually observable between many berg, wreckage, and ship drifts, on the one hand, and the particular distribution of current that the surface isotherms at the time suggest, on the other. This raises grounds for hope that an intelligent interpretation of the isotherm curves alone can be used to forecast future berg drifts, at least in some regions and cases.

Let us examine the isotherm and ice charts of the 1928 and 1929 ice-patrol seasons and see how much the isotherm charts in their present state of development can be depended upon to indicate berg drifts. The charts should be considered with the usual drifts of bergs about the Grand Banks in mind and with a knowledge of the general subsurface conditions of the region that the oceanographic station work to date has furnished. To depend upon the different isotherm charts alone would be to invite confusion and misinterpretation.

Some of the rapid berg drifts indicated by dotted lines south of the forty-third parallel on the ice charts for the months of May and June, 1928, show a general agreement with the isotherm chart for the period during which they occurred, May 21 to June 5, 1928. Comparison of three drifts shown on Figures 9 and 10 with the isotherms on Figure 28 in Coast Guard Bulletin No. 17 suffices to show this. The berg drifts during the period of the seventh and eighth patrol cruises of 1929, from July 3 to August 2, again illustrate the good correlation between the surface isotherms and the regional oceanic circulation in the area of special danger to shipping south and southeast of the Tail. To facilitate comparison the drift tracks of all of the 1929 bergs whose drifts the patrol was able to determine have been placed on the respective isotherm charts appearing in this Coast Guard Bulletin.

From the comparatively pure Gulf Stream waters just to the south of the limits of bergs many temperature reports are received by the patrol. These waters are found to be often characterized by deep embayment of the isotherms, similar to those that occur in the colder mixed waters just offshore of the Tail. Coming in with the temperature reports from the waters of tropical character there are frequent reports of spars, buoys, and other floating objects. Attention is called to the particular drift of a buoy shown on the isotherm chart for the period June 18–July 2, 1929. This buoy's drift was plotted from a series of reports each so complete and specific as to positively identify it. There were no strong breezes or gales to interfere with the local currents. It can be seen that its successive positions indicate that the local drift among the isotherm embayments in the warm water was at the time to the northwestward,

very much at variance with the ordinary conception of the flow of the Gulf Stream drift but in direct agreement with the direction of drift which would have been predicted from an inspection of the local surface isotherms on the chart.

But watching the drift of bergs and other passively floating bodies is not the only available means of ascertaining local currents. The moderate wind conditions that usually prevail in the ice-patrol area during the last half of the patrol season enable that portion of the patrol ship's own drift which is due to current alone to be rather accurately determined during times of good visibility.

The value of current determinations of this sort varies with the accuracy with which the vessel's observations of the heavenly bodies are made. Methods of position fixing by means of soundings and radio bearings, though at all times useful for check purposes, and necessarily relied upon during foggy and overcast weather, are not exact enough to be of much use for accurately determining ocean currents off the Tail of the Grand Banks. On the other hand, the positions obtainable through celo-navigational methods during favorable periods are at times dependable within a radius of not over 3 miles, and so quite valuable for this purpose.

Position fixing is of prime importance to the ice patrol for a number of reasons and great attention is paid to it. The most modern methods of handling the observational and chart work are followed. Positions are checked by independent work of at least two experienced navigators.

Spending most of its time searching relatively small areas near the temperature wall between the Gulf Stream and the Labrador Current, drifting at night, and keeping track of its position as it does, it is believed that the ice patrol is at many times particularly capable of observing the rates and directions of the local currents. Many of these currents are so restricted in size and vary so much in direction over the course of one or two hundred miles that they are frequently averaged out and lost during the long runs made daily by ships bound east and west across the ocean at speeds exceeding 8 or 10 knots.

In three cases when the ship's location was well determined strong currents were observed during the 1929 ice-patrol season, as follows: On April 25 and 26, a sustained 2.6-knot current setting east and northeast along the forty-second parallel between 49° W. and 51° W. On June 7, a current setting southeast over 2 knots near 41° 38′ N., 48° 56′ W. On June 24 and 25, a 2-knot easterly current near 42° N., 50° W. In every case the existence of these strong currents is fully indicated by the position of the curves on the isotherm charts. When a well-developed cold wall exists between the Gulf Stream and Labrador Current a rapid flow parallel to the isotherms seems to be characteristic.

One of the striking features shown by the surface isotherms southeast of the Banks is that of the tremendous embayments in the boundary between the cold and warm currents. That the warm and cold tongues are especially well developed in the middle part of the ice season is shown by the isotherm chart for the period May 21–June 5, 1928 (fig. 28 in Coast Guard Bulletin 17), and the one for the period June 3–18, 1929 (fig. 29 in this pamphlet).

Very often where an extra cold tongue from the Labrador Current extends southward on the surface an extra warm tongue will protrude north close to it and just to the westward, it would seem almost as a compensation. This sharp contrast of waters at times appears to accelerate the local oceanic circulation along the adjacent intensified temperature walls. The 5-day drift of 160 miles across the forty-fifth parallel of the southeasternmost berg of April, 1928, is not in close agreement with the surface isotherm indications in the area, but it is quite characteristic, and may be typical of the local area and the particular contemporary distribution of surface temperature. The writer believes it to be referrable to the close approximation of tongues of 42° and 54° surface water near 44° 20′ N., 45° 50′ W., which are plotted on the isotherm chart for the period April 6–21, 1928 (fig. 25, Coast Guard Bulletin 17).

Examples of berg drifts much at variance with the surface isotherm indications are easily found. Off Cape Race, along the eastern edge of the Grand Banks and close to and west of the Tail, such apparently anomalous berg drifts are frequent. Possible explanation of this condition can be found in the persistent streaming along of the layers of cold water controlling the bergs. It appears as though the cold water is at times forced under warmer and lighter surface layers, and in these cases the surface isotherms should not be taken as guides for berg drifts. To be able to detect these cases experience in the ice-patrol region or close study of the old ice-patrol records is necessary.

Before any definite statement can be made it will be necessary to determine more fully under what conditions and how regularly surface isotherm curves can be assumed to mirror the underlying circulation. Present indications are that this is the case and that valuable information can be obtained from them in the cases where and when a cold wall is strongly developed. By a cold wall is meant a region in which the surface isotherms are noticeably packed. It is a narrow belt across which the surface temperature gradient is much greater than it is farther on in either direction along the line drawn at right angles to the different isotherm curves.

The dynamic investigations have shown that the density wall, which usually controls the circulation, normally lies a variable distance inshore of the cold wall in the Grand Banks area. When depending on the surface temperatures alone the exact location of

the density wall is, of course, unknown. Nevertheless, in cases where a cold wall is strongly developed, it appears that the following rule holds good. An observer stationed along the junction line between markedly warmer and colder water, will, if he faces directly toward the cold water and puts the warm water at his back, have the local ocean current in his immediate vicinity, both behind and before him, flowing from his left-hand side toward his right-hand side.

This is not advanced as any general rule for the Northern Hemisphere or even as an infallible one for use in the whole of the 150,000 square sea mile most probable ice area about the Grand Banks. At some times and in some places the varying relations between different water masses are affected by earth rotation, winds, shoals, and other factors too much for that. There are complications caused by shifting of surface and subsurface layers from their original positions, and masking effects due in place to late season surface warming over true cold water. Nevertheless, the rule is a good working one for the ice patrol when it is used with due regard for the special dynamic and other circulation conditions that are liable to be encountered.

When the horizontal surface temperature gradient is small, and in the localities liable to subsurface pushes of cold water the case is not clear. Nevertheless, the surface isotherm charts are already of such great value to the patrol for the estimation of berg drifts that every effort should be made to improve their character, regardless of whether or not the dynamic oceanographic maps are continued.

It is certain that the isothermal method is susceptible of greatly increased development, mainly through increasing the number of incoming water-temperature reports. Such an increase in number would be very desirable even if the values were not useful for constructing surface isotherm charts. These reports serve to keep a close check on the positions and courses of the different passing vessels, inform the patrol what areas are being searched for ice, and tell what weather conditions are prevailing in different localities.

An average of 60 water temperature reports per day were received during the 1929 ice season. If this could be increased to 100 reports per day the value of the isotherms for estimating currents and berg drifts would be more than doubled. The value of the isotherm charts would be greatly increased by a few more reports per day if these could be obtained from vessels crossing the ocean between the United States and the Canadian tracks. Requests for water temperatures from this area are often inserted in the broadcasts in order to obtain more values from the little-frequented parts of it. An increase in the total number of temperature reports and a little better distribution of them would permit the making of a valuable isotherm chart weekly instead of every 15 days and would also permit a slight

reduction in the temperature interval between some of the isothermal lines.

Any final general statement at this time of the value of the isothermal method of determining ocean currents in the Grand Banks region would be premature, however. The whole matter of correlating berg drifts and surface isotherms is now under critical study. The drifts of bergs during the 1930 ice season will be closely watched for instances of their adherence or nonadherence to the isothermal indications. They should furnish considerable additional data upon which to judge the merits of the case.

B. DYNAMIC CURRENT MAPS AS BASIS FOR PREDICTION

Another method, distinct from the examination of surface isotherm curves by experienced observers, has been suggested for prediction of iceberg movements. It involves the construction of dynamic current maps, and is undoubtedly accurate when certain conditions are fulfilled. To make good current maps of this kind, however, a more detailed dynamic mapping of the area is necessary than the ice patrol can usually undertake. Therefore, under the present conditions it is impossible to get the maximum obtainable amount of benefit from this method.

How an exact knowlege of the temperatures and salinities prevailing at the different levels throughtout an area permits the construction of a current map showing the local oceanic circulation has been fully explained in the Coast Guard bulletins describing the ice patrols of 1926, 1927, and 1928. Coast Guard Bulletin 14, December, 1925, gives detailed information telling how such maps can be made and interpreted. Some idea of the effort which the ice patrol must put forth to do satisfactory dynamic oceanographic work will be obtained from the discussion which follows.

Because of rapid mixture of warm Gulf Stream and cold Labrador Current water, the ocean currents off the Tail and the eastern slope of the Grand Banks are in a particularly active state of turmoil and fluctuation. Therefore, to be sufficiently comparable, dynamically, to give satisfactory current maps, the different oceanographic stations within an area about 100 geographical miles square must be occupied during a period of not over 10 days. The results would be more reliable and lasting if the stations were taken within a period of seven days. To confine the station work to an area smaller than 100 sea miles square, or to an equivalent rectangle of less than 10,000 square geographical miles, would be to limit so seriously the scope over which the berg-drift predictions could be made as to make the current map of very small practical value.

The time during which the taking of a series of stations can be safely spread out will vary much with the rate of change of location of the different water masses in the area under observation. The

7 to 10 day periods mentioned above represent the estimated time lapse which the writer considers permissible for a set of observations taken under the usual conditions that prevail in the various 10,000 square geographical mile areas located over the deep water just east and southeast of the Grand Banks.

A case of shift of position of water masses due to time lapse can be seen when stations 1078 and 1091 are compared. These were occupied within 10 miles of each other, but the interval of 21 days between them prevents a reasonable dynamic comparison of the two water columns. In the period between the taking of the first and second of these stations a lighter water column appears to have pushed inshore toward the eastern edge of the Banks. The warming of the surface layer can be attributed to seasonal effects, but this cause can not explain the large temperature rise of the 125 and 50 meter levels. The salinities at all levels above 750 meters are much alike at the two stations. The considerable difference in temperature values at some levels can best be explained by postulating an inshore invasion of warm water.

Fifty stations, taken within the stipulated 7 to 10 day period, are about the minimum number that can give a current map of a 10,000 square sea-mile area of sufficient accuracy to be of much real practical value to the ice patrol. From the experience of the past four years it is known that 50 stations, arranged in five rows 20 miles apart, with 10 stations in each row spaced at intervals averaging 10 miles, would suffice to give a dynamic current map showing in some detail the complicated local currents of a 100 sea-mile square area.

When completed, the dynamic current maps are interpreted much like weather maps, but the stations must be placed much closer together than the Weather Bureau's observing stations if the complicated detail of the water circulation is to be caught. They must be spaced much closer about the Grand Banks region than similar oceanographic stations taken for like purposes in parts of the ocean where erratic currents due to mixture of radically different water masses are absent.

The hydrographic station values need not be regathered so frequently as meteorological observations at weather stations. It is well that this is so because it is much more tedious and difficult to get the required dynamic data properly at an oceanographic station than it is to observe the meteorological elements at an ordinary Weather Bureau station. The great mobility of the atmosphere requires the weather map to be remade from the synoptic data every 12 hours and in the sea off the Grand Banks where the currents are especially complicated and interlocking, the stations must be taken, as stated previously, within a 7 to 10 day period and comparatively close together to get the full story of the sea-water inter-

actions. Because the current speed and the mobility of the ocean swirls are of the order of twenty to forty times less than that of those in the atmosphere, the current maps when once made are probably good for about one week, though it is doubtful if the detailed current map of the hypothetical 10,000 square sea-mile area made during the course of 7 to 10 days, can be depended on very closely after three or four days from its completion, due to the length of time required to develop it.

Taking the most favorable arrangement of courses possible, to make a good useful current map of the 100 sea-mile square area with 50 stations as outlined above, it is necessary to steam about 600 sea-miles. At 8 knots, a high average speed for a scientific ship to maintain under the conditions prevailing about the Grand Banks, this would take 75 hours. Add 50 hours to this for the time required for work at the 50 stations, and a period of 125 hours, or just over five and one-sixth days, of intensive undivided work by a ship in midocean is seen to be necessary to gather the data required for the making of a dynamic current map of what is really a very small portion of the usual ice area south of the forty-eighth parallel.

During a large part of the station taking period good visibility should prevail, for it is very necessary to insure accurate geographical location of at least a number of the stations to keep the whole map from being hazy and indefinite. In places near the edge of the Banks radio bearings and sonic soundings serve to locate position rather accurately at times, but in most places many and good celo-navigational observations are absolutely essential to satisfactory position fixing. Observations can only be obtained during weather excellent for ice searching.

If the very exacting oceanographic work inseparable from the construction of detailed dynamic current maps is seriously prosecuted, the primary object of the patrol, the location by scouting and radio information of ice for the protection of shipping, must be neglected to an appreciable extent. Each time, before commencing upon the cruising necessary to the construction of a current map, the commanding officer of the patrol ship must weigh the possible advantages to be obtained from a dynamic current map against all features inimical to the practical program that such construction will entail. A current map made at the expense of a vessel's disastrous collision with ice which might have been averted, but for the oceanographic work, would involve a cost entirely too high to pay. A single patrol ship can either make current maps or stay with the ice. It can not do both at the same time with any degree of justice to either.

Apart from their practical value to the ice patrol, dynamic current maps have a permanent scientific value which is not interfered with by delay in plotting them. A number of current maps in the Grand

Banks region have already been made, however, and it would seem to be established that they can be made, and that they can be made again whenever necessity arises. A close study of maps already on hand would now seem to be in order, rather than a multiplication of maps of very transient value to the patrol.

During very light ice years, and at times when all the bergs are 200 miles or so to the north of the steamship tracks being used between Europe and the United States, an ice patrol with one vessel only out on duty might be justified in devoting itself to the tasks of dynamic oceanography to the extent of attempting to make detailed current maps of 10,000 square sea mile areas. Even during such times, however, such a procedure is open to question. When the Europe-United States tracks are not endangered by ice it would seem to be but logical to devote attention to actual patrolling along the southernmost routes between Canada and Europe. The ice patrol, besides being international in name, is entirely so in fact, receiving its support from international contributions, and therefore bound to protect impartially to the limit of its ability all the ice-endangered tracks across the North Atlantic.

Putting aside this possible exception during light ice years and periods, it would certainly seem that the ice-patrol service as now conducted, that is with two ships alternately out on duty, should most emphatically not devote its activities to oceanography to the extent required for the construction of good dynamic current maps. Depending upon poor current maps is worse than not having any at all. The real solution of the dynamic mapping problem lies in the employment for the ice-patrol duty of an additional vessel, charged primarily with the scientific work.

3. ESTIMATE OF TOTAL ANNUAL AMOUNT OF GLACIAL ICE SOUTH OF FORTY-EIGHTH PARALLEL, AND ITS TOTAL CHILLING EFFECT ON THE WATER

It has been argued by a certain school of scientific thought, influenced by the oceanographer, O. Petterson, that the bergs about the Grand Banks in melting furnish the energy which keeps the southern reaches of the Labrador Current moving along as they do. On the other hand, others, and especially F. Nansen, contend that melting icebergs have little effect in producing great ocean currents.

Attempts to estimate the total amount of glacial ice that comes south of the forty-eighth parallel in any one year and to consider its possible chilling effect on the water masses there may throw some light on this problem. If it is a fact that a negligible amount of cold water is produced by the melting of the bergs that get south of the forty-eighth parallel in the Labrador Current, it will be reasonable to suppose that their melting will be unable to have much effect on the hori-

zontal ocean currents that exist to the east and south of the Grand Banks plateau.

In 1929, the heaviest ice year that the international ice patrol has experienced to date, approximately 1,300 bergs drifted south of the forty-eighth parallel in the Western North Atlantic. When it crosses the forty-eighth parallel the cubical contents of the average berg, above water, is not greater than that of a block of ice 100 feet high, 400 feet long, and 100 feet wide. That means that the average berg has, above water, not more than 4,000,000 cubic feet of glacier ice. Lieut. Commander Edward H. Smith, a former ice-observation officer of the patrol, estimates the average above-water volume of bergs about the Grand Banks to be one-third of this amount. However, a certain amount of glacial ice in the form of growlers crosses the forty-eighth parallel each year. To allow for this ice, and to insure that the total quantity of fresh-water ice will not be underestimated, a rather larger average size has been allowed for the bergs than would otherwise be the case.

It is quite likely that a fair estimate of the correct annual total amount of above-water glacial ice that enters the region about the Grand Banks will be obtained by multiplying the total number of bergs given by the ice patrol as south of the forty-eighth parallel each year by 4,000,000 cubic feet. This figure is advanced as a maximum one, the real amount being probably somewhat smaller, due mainly to duplication of berg reports.

The total amount of ice to come south of the forty-eighth parallel is, of course, the sum of that which is above and below the sea surface. The underwater body of a berg being quite irregular and largely hidden, its total volume is extremely hard to determine by actual observation or measurement. In the past it has undoubtedly been overestimated. The fresh-water glacial ice of the North Atlantic iceberg is, according to experiments made by the physicist, H. T. Barnes, about 10 per cent lighter than the solid ice which is formed on the surfaces of lakes and streams in winter. The reason for its lightness is found in the much larger proportion of air in the form of tiny bubbles that it contains. All the pictures of ice in this bulletin show how white and clouded with innumerable tiny air bubbles the glacial ice of icebergs really is. According to Barnes' estimate its specific gravity averages close to 0.830 as compared with about 0.916 for clear ice and 1.000 for pure water at the point of maximum density.

Since nearly all of the bergs to the south of latitude 48° N. float in sea water of density varying between 1.02 and 1.03, they must float on the average about one-fifth out of water instead of one-eighth. Until recently the latter figure has commonly been accepted as approximately correct, but if Barnes is right, it is entirely too small.

The actual range of density of glacial ice in the Grand Banks region should be checked by more observations.

The size of the average berg has been taken great enough to insure that no large underestimation can be introduced into the final figures by the slight uncertainty that still exists relative to the average specific gravity of the ice. Therefore, multiplying the average berg's 4 million cubic feet of above water ice by five, we find that on entering the waters about the Grand Banks it contains not over 20 million cubic feet of ice in all, or, in other words, has a total mass slightly in excess of 500,000 short tons.

The total amount of berg ice, both above and below water, south of the forty-eighth parallel in 1929, may, therefore, be estimated as thirteen hundred times 20 million or 26 billion cubic feet, which is roughly about 676 million short tons. Such an amount of ice would require well over 100 trillion British thermal units to reduce it to water at 32° F. This is a formidable amount of heat, for each British thermal unit is equal to 252 gram calories.

It is with this draft of heat that icebergs melting south of the forty-eighth parallel directly affect the temperature of the waters in which they are distributed. As soon as the area in which the 26 billion cubic feet of ice melts is estimated, the possible effects on water layers in the area can be computed.

The isotherm and ice maps show that the cold waters that would be directly affected by this melting ice extend over about 20,000 square sea miles south of the Tail, 30,000 square sea miles along the eastern edge of the Banks, and 24,000 square sea miles between the forty-seventh and forty-eighth parallels. (See figure 1.) This is a total area of 74,000 square sea miles or 2,644 billion square feet.

Hereafter this area will be referred to as the "melting area." The section of it to the south of the Tail, and the southern half of the section of it along the eastern edge of the Banks, include the whole of the 13,200 square sea-mile critical triangle of the patrol described in the chapter on procedure and remarks. They include the waters that surround the critical triangle as well. The northern parts of the "melting area" include all waters through which the bergs pass to reach the critical triangle.

It was also stated in the discssion of the practical problems of the patrol that berg ice is normally found each year inside a 150,000 square sea-mile area south of the forty-eighth parallel. The "melting area" is the very heart of this usual ice area, and inside of it fully 90 per cent of the ice that comes south of the forty-eighth parallel can be expected to melt. To draw comparisons so that the size of the "melting area" can be more readily visualized, its 74,000 square sea-mile extent is a little larger than the six States that comprise

New England, and a little smaller than the combined area of England and Scotland.

Without attempting to discuss the vertical circulation that takes place within the radius of a mile or so from a berg melting under the varying weather and water conditions that it encounters during its life span in the Grand Banks region, it is certain that the bergs do chill sea water there in melting. It makes no difference in a discussion of their total chilling effect whether they affect surface or subsurface layers. From whatever stratum the heat is chiefly drawn, the total amount consumed will be the same.

Let us assume that the bergs directly affect a layer of water averaging over the 74,000 square sea-mile "melting area" 50 feet thick. This is a minimum thickness to expect them to affect and a convenient one for calculations. It gives 133,200 billion cubic feet of water in the "melting area" to be affected by the disintegration of the total of 26 billion cubic feet of glacial ice. Simplifying the problem, it is found that for each 5,123 cubic feet of water there is 1 cubic foot of ice.

The latter is very close to 32° F. in temperature when it crosses the forty-eighth parallel. Neglecting the lightness of the glacial ice, and the salinity of the sea water, and generously allowing that 80 cubic feet of the latter can be chilled 1° F. by the melting of 1 cubic foot of the ice, it follows that the melting of the total amount of glacial ice present throughout the whole ice season in the region under discussion would only counteract the normal seasonal warming of a 50-foot layer of water in the melting area south of the forty-eighth parallel by 0.0156° F., an insignificant amount.

It should be borne in mind that the 1929 ice year, on which the 26 billion cubic-foot berg ice total used above is based, was an ice year about three times as heavy as the normal one. It is safe to say that during the normal year, when less than 400 bergs come south of the forty-eighth parallel, supplying the heat requirements of the glacial ice disintegrating in the "melting area" does not chill any 50-foot stratum of water in the cold current there by more than 0.01° F.

It has been assumed in arriving at the above estimate that no chilling effect from the bergs is lost directly to the air. This loss exists, but it is doubtless extremely small. It has been further assumed that no locally ice-chilled water is lost from the "melting area" to the westward past Cape Race, to the westward to form bottom water over the Grand Banks, or to the southeastward past Flemish Cap. Analysis of berg drifts shows that, during the ice season at least, there is but little push of cold water to the westward past Cape Race or onto the Banks. Some losses in these directions occur, however, and even more ice and cold water are lost to the southeastward past Flemish Cap. The sum total of losses in all three directions probably amounts

to well over 5 per cent of the effect of the melting bergs. The larger this percentage loss is, the less will be the chilling effect on the local waters of the bergs that melt in the "melting area."

The 0.01° F. figure is a maximum for still another reason not previously brought out. During a 100-day ice-patrol season, the cold current is entirely renewed at least once throughout the "melting area" if the average southerly drift of the current is only 4 sea miles per day. But the southerly drift of the ice bearing waters averages much more rapid than this. Therefore, the chilling effect of the season's bergs should not be figured upon the simple extent of the 74,000 square sea miles. It should be spread out over a water volume covering a surface more than twice as large, over the total area of cold water that passes through the "melting area" during the ice season.

These conditions need not be emphasized because the approximate figure of 0.01° F. which was arrived at is already sufficiently small to indicate the relative unimportance of the bergs as chilling agents in the southern reaches of the Labrador Current. Even if very large miscalculations have crept in, and the total amount of berg ice to get south of the forty-eighth parallel should by any chance be twice as large as has been estimated, still its effects will be so small as to make them extremely unimportant.

An oceanic effect diametrically opposite to the chilling influence of melting bergs is to be found in the vernal warming at and near the surface about the Grand Banks. The next paragraphs will discuss that part of the tremendous seasonal warming which the ice patrol is able to observe, and will compare its magnitude with the 0.01° F. chilling value just deduced.

The normal ice-patrol season can be taken as 100 days long, from March 25 to July 3. A slight amount of exterpolation is necessary to arrive at the March 25 and July 3 surface temperature values in years when the active patrol season begins late or ends unusually early. On the whole such allowances are easy to make and the ice-patrol period can be used as a convenient measuring stick.

Since the normal ice-patrol season extends from just past the vernal equinox to well past the time of the sun's most northerly declination, the sun has a high position in the heavens at noon, and the surface waters warm up rapidly over the whole Grand Banks regions throughout the time. Although there are large local variations, and also annual variations of less amount but larger significance, comparison of the patrol's surface isotherm charts show that the rates and amounts of warming in the same areas in different years agree closely.

At the beginning of the season, just before April 1, the temperature of the Grand Banks surface water is about 33° F. At the close of the season, a little after July 1, it is about 55° F., a rise of 22° F. Over the varying extent of cold Arctic stream water south of the Tail, the

temperature is about 33° F. at the start of the season and 50° F. at its close, a rise of 17° F. Along the eastern edge of the Banks the true cold water rises from about 32° F. to about 47° F., a rise of 15° F. Between the forty-seventh and forty-eighth parallels the Labrador Current surface water during the same time warms from about 32° F. to about 44° F., a rise of 12° F. South of the Banks along the fortieth parallel in the Gulf Stream the rise during a 100-day ice-patrol season amounts to 10° F., from about 60° to 70° F.

The varying rates of warming in different areas about the Grand Banks are in the main easily accounted for. The Grand Banks water, for instance, is shoal and it is somewhat less subject to fog blankets than the Labrador Current. Moreover it is relatively stationary in so far as the effects of true ocean currents, as distinct from tidal ones, are concerned. It is, therefore, favorably situated to show a high degree of vernal surface warming.

On the other hand, the surface water of the southern parts of the Labrador Current is constantly being replenished by cold water from the north. It is underlaid by extremely cold water and overlaid by much fog throughout the season. The effects of solar warming show up slowly and it is easy to see why it only warms up 14⅔° F. on the average during the time in which the Grand Banks surface waters are warming up 22° F.

The Gulf Stream's small surface warming despite much clear weather can be attributed principally to the fact that its waters are already warm. It is flowing with a large northerly component into cooler regions of decreased sun strength where radiation and other losses can with less and less facility be counterbalanced.

The area of mixed surface water between the Gulf Stream and the Labrador Current changes position and size rapidly, varying so much from month to month and year to year that it is hard to say just what its exact increase in temperature is. A fair figure would be one somewhere between that of the pure Labrador Current and Gulf Stream surface water, say 13° F.

Coming back to the 74,000 square sea mile "melting area" it can be seen that, though principally over the Labrador Current, it slightly overlaps the Banks, and extensively overlaps the mixed water offshore. Fourteen degrees Fahrenheit can be taken as a good figure for the total rise of its surface water temperatures during the 100-day ice-patrol season. The warmed waters tend, of course, to remain near the surface of the sea, hence the warming effect decreases rapidly with depth throughout the Grand Banks region.

Let us assume that the rise of temperature at the 50-foot level in the "melting area" during the ice-patrol season is 10° F., as compared with 14° F. at the surface during the same time. The stations which the ice patrol has taken in the area usually sample the surface, the 25-

meter, and lower levels, and tell nothing directly about the temperature of the 50-foot level. Nevertheless, a study of temperature curves made from the station figures shows that 10° F. is a conservative estimate to make for the average increase in temperature at the 50-foot level between March 25 and July 3.

Let us neglect the tremendous sum total warming that takes place in decreasing increments in the 50-foot layers of water below the 50-foot layer that has its upper boundary at the surface of the sea. We can for the purpose of this discussion simply assume that the total effect of solar warming from March 25 to July 4 is not less than enough to warm all the water from the surface down to the 50-foot level in the "melting area" an average amount of 12° F.

Now a rise of 12° F. in 100 days means that the average rise is 0.12° F. per day. It has been shown that 0.01° F. is a very generous amount to allow for the chilling effect of a full season's bergs south of the forty-eighth parallel on a 50-foot layer of the "melting area." One one-hundredths degree Fahrenheit is only one-twelfth as much as the average daily rise of 0.12° F. In other words the total chilling effect of bergs in the "melting area" is not sufficient to nullify more than two hours of the average vernal warming effect that is active throughout the ice-patrol season.

This seems hard to believe at first when one looks at the ice charts of the ice patrol. It must be kept in mind that the bergs marked on these charts must be large enough to be plainly seen. As drawn they are far too big in proportion to their proper scale size. The real amount of glacial ice south of the forty-eighth parallel each year is comparatively small when considered in relation to water volumes of 50-foot layers of the "melting area."

One way to get a conception of the relative smallness of the 26 billion cubic feet of glacial ice that came south of 48° N. during the heavy 1929 ice season is to assume it to be spread out evenly over the surface of the "melting area," of 74,000 square miles, or 2,664 billion square feet. The whole season's bergs spread out at once would make a uniform layer of glacial ice only about 0.01 foot, or one-eighth inch thick.

A skim of ice only one-eighth inch thick would not be expected to last long or to interfere much with vernal warming of a fresh-water lake. It should be expected to last far less time and to interfere with warming no more over the "melting area." On second thought the comparatively negligible effect of the bergs south of the forty-eighth parallel on the water masses there is seen to be quite plausible.

It is recognized that none of the variables that have been considered in arriving at the conclusions reached in this section are accurately known. Therefore, the results can be only approximate and can only serve to give an idea of the orders of magnitude involved. In cases

of doubt large values have been taken to arrive at the chilling effects of the bergs, and extremely small values to arrive at the total effect of vernal warming. For this reason the estimate that the melting of bergs south of the forty-eighth parallel offsets the solar warming effect in the "melting area" by but two hours is likely to be much too large. The true time figure is probably less than one hour. But even if gross errors have crept in and the two hours should be 100 per cent too small instead of too large, the negligible effects of the melting bergs in the southern parts of the Labrador Current would still be apparent.

If the bergs melting south of the forty-eighth parallel do not make and keep the southern reaches of the Labrador Current cold and active, then what does? The answer to this question leads very far afield and can not be more than hinted at here.

Barnes [1] sees the source of the cold water layers in the Gulf of St. Lawrence and southeast of Newfoundland in the melting of icebergs. Lieut. Commander Edward H. Smith, United States Coast Guard, has stated in the course of conversation with the writer that, because of their large size and immense numbers, the melting of bergs north of the forty-eighth parallel has a much more powerful effect than that of bergs melting in the "melting area." The sum total of the berg effects, in his opinion, amounts to almost nothing, however. It is many times exceeded by that of melting northern field ice. He further stated that the combined effects of both bergs and field ice were entirely inadequate to account for the enormous volume of cold water that is discharged annually past Labrador by the Labrador Current. He contends that its true source must be looked for in direct winter chilling of the sea in northern regions by the air.

He bases his opinion on a critical study of all the important oceanographic and explorational work that has been undertaken in the North Atlantic and polar basins, as well as on the results of his own work while with the ice patrol and the Marion Expedition. The latter scientific expedition into the waters between Greenland and Labrador, it will be remembered, was sponsored by the United States Coast Guard for the benefit of the scientific program of the ice patrol in 1928. The results of its work have not yet been fully published, but will be issued from time to time as special numbers in the series of Coast Guard bulletins. Lieutenant Commander Smith has just finished his discussion of ice and currents, and these sections, embodying his views, a few of which are briefly outlined above, should appear at an early date.

It is believed that the calculations of chilling and warming effects made in this section will help in a small way to support the Nansen idea of oceanic circulation as interpreted by Lieut. Commander Edward H. Smith.

[1] P. 75, Transactions Royal Society of Canada, 1914, Sec. III, third series, vol. 8.

4. OBSERVATIONS ON ICEBERG DISINTEGRATION SOUTH OF THE FORTY-FOURTH PARALLEL

One might assume that the ice patrol as now conducted has more frequent and better opportunities actually to observe the disintegration of icebergs and field ice than is the fact. There are some opportunities for first-hand observation, of course, but these are often not so good as might be wished. For instance, during the writer's four years' experience with the ice patrol he has never seen a single square foot of the field ice that is so abundant during the early season in the northern parts of the Grand Banks region. The reason for this is that the patrol must almost always remain close by the southernmost ice limits. About these limits the field ice is not usually found, and even the bergs themselves are rather few and far between.

Frequently after a day of searching a berg reported earlier by a passing vessel is found late in the afternoon after the completion of a predetermined search pattern. It is usually given a berth of from one-half to one-fourth mile, though sometimes it is passed closer, depending upon weather and other conditions. The ship will then be stopped 1 or 2 miles to leeward of the berg, where it is "secured" for the night—that is, steam is turned off the propelling machinery and the larger generators and auxiliaries, to save fuel for future searches for ice.

When daylight returns next morning the berg is usually only a small white mass on the horizon. It may even be 8 or 10 miles to windward, on account of the relatively greater effect of breezes on the ship and surface water than on the deep-lying berg. It may be approached again before the new day's search is started, but in many cases it is only relocated from a distance by a series of bearings taken with the aid of the gyrocompass repeaters on the wings of the bridge. Such bearings can locate the geographical position of the berg as well as steaming up to it, and they can be taken while the ship is running along on a set of courses planned to make the new day's search for ice most effective.

Possibly the patrol will return to the old berg for the night, and if this is done, a comparison can be made with the way the ice looked 24 hours earlier. But new bergs that require watching may be found in more threatening positions than the old one, and if this is the case, the former may never be seen again.

Each season a few of the most southern bergs are watched during a period of days. Then the usual procedure is to drift well clear of the ice and to run up toward it once or twice a day, in the evening, or both morning and evening, depending on the rate at which the patrol ship is drifted or blown away.

During about one-third of the ice-patrol season fog makes all continued observations of ice impossible. Bergs under surveillance when

a long period of fog shuts down are invariably lost. After a protracted foggy spell the patrol does its most intensive cruising, trying to relocate the new positions of the dangerous bergs.

Each year a certain amount of time is lost in futile searching for bergs reported from extra southerly locations. These bergs frequently can not be found because of the strong currents and rapid ice disintegration, which obtain in the warm surface waters along the northern edge of the Gulf Stream.

Besides the rather limited opportunities for close first-hand observation, the varying shapes of the bergs themselves, and the varying conditions of wave motion and water temperature about them, all go to make the subject of berg disintegration a complicated and conjectural one. The determination of the life of a berg that is sighted south of the Tail of the Banks is certainly not obtainable through the application of any hard and fast rules.

Obviously 130,000 tons of ice in the form of growlers and small pieces will melt much faster than the same amount of ice in the form of a single solid berg. Not only will the smaller pieces have a greater total area exposed to water action, but they will be entirely in the upper layers of water that are warmer and more affected by wave motion than the layers that are 50 feet and more below the surface. The pieces of ice that calve from a berg nearly always stream off to leeward, under the influence of winds, waves, and surface currents. They rapidly melt and disappear and the life of the parent berg is undoubtedly materially shortened by continued prolific calving. Some of the bergs, because of their peculiar shape and particular internal structure, or the unusual conditions of water and weather that they experience, calve more than others.

The fresh ice exposed when a piece falls from a berg south of the forty-fourth parallel is dry and frosty at first. The spot, even though far above the reach of sea and spray, soon becomes wet, however, and so it generally remains. After long exposure the upper parts of bergs sometimes become rough and granular and apparently dry, while between the granules they may be wet in fact.

Barnes [2] states that bergs calve most near sunrise and that they dry up and freeze on account of radiation from their surfaces at night. This may be true of bergs north of the Grand Banks, but that it is true of bergs melting in the warmer southern portions of the "melting area" south of the forty-fourth parallel should not be assumed without more direct evidence. On the contrary, the late afternoons, nights, and early mornings are foggy or cloudy more than 50 per cent of the time during the ice season in the southern parts of the "melting area." Such conditions are not conducive to effective nocturnal chilling of berg surfaces by radiation and keep as well the early rays

[2] H. T. Barnes, "Thermit and Icebergs." Journal of the Franklin Institute, May, 1927.

of the sun from striking the ice. During 1929 one berg southeast of the Tail approached on a cloudy night was seen when the beams of a searchlight were played on it to be pouring off water from all visible surfaces, just as so usually happens during the day.

Notwithstanding the need for further observation and study, the observations which the ice patrol has been able to make to date permit some conclusions to be drawn about the life of bergs south of the forty-fourth parallel. Two late instances will be given.

A berg of not less than 500,000 short tons mass was seen by the patrol for the first time on July 17, 1929, about 55 miles south-southeast of the Tail. It was in water close to 60° F. at the surface at this time and remained in such water throughout the remainder of its life. It disappeared entirely late on July 26, nine days after it had been first sighted. The berg was a rather solid one and this disintegration was considered quite rapid. A berg of about the same size in 1928 lasted south of the Tail from May 21 to June 4, a period of 14 days. The time was earlier in the season and the water was considerably colder during most of this time. In fact, it was in surface water colder than 38° F. from May 21 to May 25. Both of the above bergs were larger than the average berg that gets below the forty-fourth parallel, being of the approximate size of the generously large berg taken in section 3 of this chapter as the average size which crosses the forty-eighth parallel.

The experience of the ice patrol all goes to show that in the 50° to 60° surface water south and east of the Grand Banks the average berg can be counted on under all ordinary circumstances to be entirely melted in from 7 to 10 days. Only extremely large and resistant bergs are able to survive longer in water warmer than 50° F.

It was computed in the section of this chapter dealing with glacial ice totals that the abnormally heavy 1929 ice season provided only enough ice south of the forty-eighth parallel to cover the "melting area" of 74,000 square sea miles with a film of ice one-eighth inch thick. The only reason why the glacial ice reaches so much lower latitudes and persists south of the forty-eighth parallel each season two to three months longer than the field ice does is because of its concentration in the large masses known as icebergs. If it were not so concentrated it would vanish overnight and never reach the 50° and 60° water east and south of the Banks.

The field ice so prevalent during the first third of the ice patrol season in the northern half of the "melting area" and in the regions to the north of that, has an enormous preservative influence on the bergs. If there were no field ice off the Labrador and Newfoundland coasts in the winter and spring there would be far less of a berg problem along the trans-Atlantic tracks than there now is. The field ice has been credited with acting as a fender which keeps the

bergs during certain months from grounding along the North American coast north of Cape Race, and so eliminating themselves from southern waters. Whether this be true or not, it is an undeniable fact that the field ice tends to keep the surface water about it ice cold. A berg surrounded by field ice in the Labrador Current until it is south of the forty-fifth parallel is conserved much as a cargo of meat is conserved in a refrigerating vessel that is steaming through the Tropics.

But the field ice prolongs the life of the bergs in another way than through its great cooling effect. In addition it effectually prevents the development of wave motion, and in this way protects most efficiently the vulnerable waterlines of bergs from the washing and melting attacks of moving surface water.

Calving most frequently takes place by the dropping down of ice masses that overhang an undercut water line, and so is closely related to surface water attacks. Calving upwards from the smoothly rounded underwater portions of a berg is exceptional in the ice patrol regions. Sometimes a projecting spur that is mostly submerged is broken off by stresses arising from the rise and fall of the swell. These stresses are very large at times, and so are the blows of the sea against a berg's sides. Bergs are usually very dead in the water and take the full force of the seas like rocks. They do not normally roll or ride over the seas like well-designed ships do when drifting.

Calving generally involves but a very small portion of the mass of a berg at any one time. Of course bergs sometimes break up into two nearly equal parts, but in fully 90 per cent of the cases the amount of ice involved in a calving is so small in comparison with the mass of the berg that equilibrium is only slightly affected. This is the case, even when the meaning of calving is restricted to production of ice volumes of more than 1 ton. The breaking off of small pieces is very frequent under some conditions, and this production of small amounts of ice in the form of chips and tiny blocks is not considered real calving, such as is contemplated here.

It is reasonable to suppose that the chances of calving and rolling will be much greater in warm water than in cold, but it must be remembered that the conditions will vary much with each individual berg. To venture an opinion for the benefit of those who in the future may be called upon to work upon bergs for any purpose, it is estimated that the average berg south of the forty-fourth parallel can be expected to have natural calvings involving the falling off of over 1 ton of ice about three times a day, and to experience changes of position involving the turning about an axis more than 60° in less than one minute of time about twice a week. The above is only a rough estimate, based on comparatively few observations. Some bergs will not calve for days at a time and will never turn over until

they have been reduced to the size of a ship's boat. Other bergs will both calve and roll about much more than the average.

The varying water temperatures in which a berg may be floating have a great effect on its speed of disintegration, but it is doubtful if the percentage of the total wastage due to calving, compared with that due to direct melting from the berg, varies much under any conditions met south of the forty-fourth or even the forty-eighth parallel. The effects of calving are more noticeable in some cases than others, however. For instance several bergs seen near the Tail in 1929 had water lines showing that the upper parts of the berg were rising higher and higher out of the water. They were very few in number, and they may be explained by excessive calving, or by floating in very cold sub surface water during periods of warm bright weather that were especially destructive to large portions of their above-water bodies.

Nevertheless, despite low temperatures of surface water at all places during the early season, and in many places until close to the end of the ice period, and despite permanent low temperatures at the lower levels reached by bergs in the "melting area," the constant effect of the sea water moving about in intimate contact with the water line and the great underwater surfaces of bergs must be the most important factor working toward their destruction. Subaerial melting from the bergs is a minor factor, but still it adds its quota to the melting process of berg disintegration, as distinct from the loss of mass through calving. Over the whole ice-patrol area the sum total calving effect is probably much less than the total surface melting effect in getting rid of the bergs.

From a small boat that pulled about a berg which pitched heavily while calving on July 15, many air bubbles were seen to be rising through the smooth water and breaking at the surface within a dozen feet or so of the vertical ice walls of one side. Some of these bubbles appeared to be nearly 1 inch in diameter and these made a considerable disturbance at the surface like the large bubbles of marsh gas that rise through shallow waters under certain conditions. Each of the larger bubbles of gas in the case of the berg were undoubtedly made up from the combined contents of many of the formerly imprisoned tiny air bubbles of the glacier ice. The separate air bubbles in the bergs are generally less than one-thirty-second of an inch in diameter, much smaller in size than the head of an ordinary common pin. The particular berg of this instance was floating in surface water of temperature 57° F. The continuous coming up of air around it is good evidence of the rapid underwater wastage which occurs whenever the water is that warm.

When movement of the slight swell exposed portions of ice below the average water line of the above berg it was seen that the under-

water surfaces were not smooth, but dimpled. This condition was undoubtedly due to differential melting about the individual glacier grains. This dimpled effect is almost always noticeable when the water lines of bergs are closely inspected. Perhaps the underwater bodies of bergs while melting about the Grand Banks, though smoothed and rounded in general outline, may all be composed when the detail is considered of these roughened surfaces. They can be compared to nothing so well as to magnified "goose-flesh" with the intervals between the individual projections or the individual hollows of the order of about half an inch.

To mention a few more examples of berg disintegration observed during the 1929 season it can be stated that on the afternoon of July 24 the ice patrol was standing by a berg in 61° water 55 miles south-southeast of the Tail. The berg was seen to calve heavily. In a few minutes a boat put out from the patrol ship with a swimming party and a number of the growlers in the vicinity of the berg were boarded.

This could be easily be done, either from the boat or the water, without much discomfort, for the chilling effects of the ice on the surface water could be noted on ordinary ship's hold water thermometers only when within a few yards from some of the berg's ice walls, and when the boat was in the midst of a group of growlers spaced on the average 50 feet or less apart. In a few such places temperatures 58° F., but 3° lower than the general sea surface of the neighborhood, were recorded.

About the berg that pitched when calving on July 15 slightly greater local depression of surface temperature was noted. This berg, as already stated, was surrounded by sea water of 57° F. temperature at the surface. In one direction only from this berg was any chilling noted, but a depression of over 1° F. extended on this side to about one-fourth mile from the ice. Close to the berg the sea was 54° to 52° F. at the surface on this chilled side, and here, inside an ice-bottomed, well-washed bay cut into the berg behind an outlying ice pinnacle the temperature was 50° F. Among some near-by growlers a minimum surface temperature of only 48° F. was found. On the other hand, unchilled 57° F. surface water was found close to the vertical walls of the berg on the side opposite to the chilled water and growlers. The weather was calm, warm, and clear, and there was only a slight swell.

5. POSSIBILITY OF BREAKING UP ICEBERGS ARTIFICIALLY

It has often been stated that noise or small blows can break up bergs. The firing of 6-pounder blanks and the sounding of the steam whistle and siren within 100 yards of unstable looking bergs has always failed to bring down any pieces of ice at all during the dozen or more instances in which the writer has seen it persistently tried. Even

PLATE XIV.—Firing explosive 6-pounder shells into the high thin wall forming one side of a dry-dock type of berg. In this instance a number of tons of cracked ice were brought down into the sea. July 11, 1929, latitude 41° 34′ N., longitude 49° 00′ W.

PLATE XV.—Two officers from the *Modoc* on a large growler that an hour earlier formed a projecting ledge just below the water line of a near-by berg. This ice was entirely melted within 24 hours, 61-degree water, July 24, 1929, latitude 42° 10′ N., longitude 49° 30′ W.

PLATE XVI.—Fragments of iceberg hoisted aboard. This ice is hard and homogeneous. Its opacity is due solely to great numbers of tiny spherical air bubbles

PLATE XVII.—Swimming close to an iceberg in 58° surface water. This ice is not in the Gulf Stream, but is in a great pool of Labrador current water that has been highly warmed at the surface by continued vernal warming. At 100 feet below the surface the temperature was less than 40° F. The striping on the sunlit berg wall directly behind the swimmers may be due to differential melting between annual layers accumulated on the ice cap of Greenland. Taken from ship's boat July 18, 1929, latitude 42° 28′ N., longitude 50° 05′ W.

overhanging and towering ice walls and cracked pinnacles seem unaffected by such noises. Six-pounder shells will bring down from a few pounds to a few tons of ice. They are most likely to produce damage if fired into weak portions of vertical or overhanging walls. Sometimes a lucky shot placed in a crack near a pinnacle or a corner about ready to fall will serve to produce a sizeable growler.

That a berg about the Grand Banks can be noticeably shattered or affected by any such thing as the making of noises near it, or by weak blows like those from an axe should be considered as conceivable, but verging upon the extreme height of improbability. The above statement is made in spite of the following experience with a seemingly fragile berg.

One day in August, 1928, the United States Guard Cutter *Marion* was run alongside a small grounded berg off the Labrador coast for the purpose of obtaining ice. While the berg was being attacked with an axe it calved and pieces of large size thundered into the sea, pushing the vessel well clear. The action of this berg was alarming and impressive to those witnessing it, but it should not be taken as showing the great liability of bergs to disintegrate because of small blows. As a matter of fact the ice that calved off amounted to very little when compared to the total mass of the berg. The parts that fell off were located along an almost vertical, slightly undercut wall. The ice was probably just about to come down of its own accord from the internally strained, grounded berg. It did so when the ship was gently bumped against it by the slight swell, and when the men on deck struck at the ice surface opposite them with an axe.

Because of the rapidity with which bergs break up themselves, and because of the known physical properties of ice, it has been suggested that the southernmost bergs be removed from the paths of navigation by boarding and mining them. Some experiments along these lines have been carried out in past years by the ice patrol, but without much success. There are on the average 51 bergs south of the forty-third parallel each year, and to attempt to mine any large proportion of them, even if feasible, would consume much valuable time that might be devoted to ice scouting.

It has already been shown that bergs in the warm waters south and east of the Grand Banks have a life span of only 7 to 10 days. The rapidity with which they break up from natural causes throws no little element of risk into mining operations on them. The conditions are brought out somewhat in the preceding section on ice disintegration, but to evaluate further the risks the next few paragraphs have been written for the benefit of future ice patrol officers who may be called upon to experiment again with the mining of bergs.

Some bergs are very delicately balanced. Two turned over during 1929 while being passed by the ice patrol vessel. It is hard to see

why a great piece of ice riding on the swell of the open ocean should turn over when struck by the almost imperceptible waves of a vessel passing 100 yards or more away at a speed of 10 knots, but that is what seemed to take place. Many bergs, even among the number of those that project like rounded cones and hills from the sea, are so finely balanced that they require but little to make them roll over. One small rounded berg that was boarded in 1927 from a small boat off the eastern edge of the Banks turned over half an hour after the boarding party had departed. One smoothly rounded 1929 berg that was watched for about a week southeast of the Tail was seen to roll over at least once a day without any noticeable calving or breaking up.

Assuming, however, that the situation appears to be favorable, and that it is decided to attempt to mine a berg, the first problem is to get upon it. Bergs too steep to be boarded without the aid of ropes can doubtless in some cases be solved by shooting lines over them, hauling stronger lines over their summits, and fastening floating weights such as log fenders to the end of the line opposite to the boarding party.

Spiked shoes are needed to keep from slipping, and axes for cutting footholds in the hard ice are essential if any steep slopes are to be ascended. The officer in charge of the boarding party must bear in mind that, to the ordinary small boat risks attendant on landing upon and getting picked up from a large uninhabited object in the open sea must be added the danger of immersion in cold water.

The actual cold water and boarding risks approach the vanishing point about bergs in smooth water over 50° F. at the surface. But whether a berg will calve or turn over while being approached or worked upon is hard to predict. The observations of the patrol show that calving south of the forty-fourth parallel is not generally confined to any particular time of the day but is liable to occur at any time. Turning over of a berg usually occupies a number of seconds, but it is liable to occur without warning, or only after the sudden warning of a heavy crackling and calving. Probably in most cases where a berg turns rapidly through 60° or more the boats attending the working party will have the duty of pulling their charges out of the water.

Even if all parts of the berg that have towering pinnacles are avoided, there is danger that a subsequent rolling movement will cause ice to slide down upon persons on a berg. A movement in the other direction would elevate the working party and put them in danger of dropping down over cliffs to ice shelves or down into the sea upon or among closely spaced growlers.

The most stable bergs on the whole are the tabular ones. A squad of infantry could be placed upon the tops of the largest of these bergs and drilled at both close and extended order with comparative safety. In 1929 the tabular bergs south of the forty-fourth parallel were

about as numerous as the thin-walled dry-dock type or the rounded water-worn type. The undulating top surface of the tabular bergs often appears to be but a very slightly modified form of the surface of the original glacier from which the ice was set free. From a short distance it appears to be composed of rough grains about the size of marbles and it is often muddied and soiled by the abundant bird life. Many of the tabular bergs have walls that are kept vertical throughout almost all of their life history in the Grand Banks area by calving off of overhanging pieces as the waves eat into the berg about the water line

On May 31 a tabular berg approximately 115 feet high and 400 feet square was seen near the Tail, and on July 15 another large berg, seen around noon 90 miles south-southeast of the Tail, was of a form bordering upon this type. At about 2 p. m. attention was called to the latter berg by a cry from the bridge. It was calving heavily and pitching as it did so. Whenever its sheer end walls became overhanging ones they gave way, and then the suddenly lightened end of the berg would lurch upwards. This caused the process to be repeated from the other end. The berg calved three or four times in this manner during the space of about a minute. It was not over 2 miles away and could be clearly seen at the time by those on the bridge and about the decks. Soon it became quiescent very close to its former position of trim.

6. LOCAL CONVECTIONAL CIRCULATION ABOUT ICEBERGS

Barnes[3] states that melting bergs draw in the surface waters toward them and that they have warmer surface water immediately about them than is the case farther away. It is quite possible that bergs do draw in, chill, and sink certain amounts of surface water under some conditions of melting. This might easily be concluded in view of the rather small surface temperature effects described in the section of this chapter on ice disintegration.

Nevertheless it is difficult to see from theoretical consideration how bergs can do much along the line of sinking chilled water in the "melting area" south of the forty-eighth parallel. During the ice-patrol season the surface water of the region is in general much warmer and somewhat fresher than the layers 25 and 50 meters down. Such conditions indicate a marked stability of the water column, and are directly opposed to the production of vertical convection currents.

In the early season many of the bergs keep in water that is below 32° F. at all levels about them until they are well south of the Tail. Of course, in the case of such conditions they can not cause much local circulation through chilling and sinking water that they draw in

[3] Annual Report of the Smithsonian Institution for 1912, p .737.

toward themselves because of the physical impossibility of anything chilling the already frigid water by more than 1° or 2°.

Throughout the year, just below the upper 25 or 50 meters of water throughout almost all the 74,000 square sea mile "melting area," the next layers of water remain, in general, very cold. At many stations 38° and 37° F. water is found just below the 25-meter level, even though the time may be June or July, and 50° to 55° F. water may be encountered at the surface.

Let us consider the conditions that prevailed in the upper portions of the water column at station 1085. That station was taken at 42° 01′ N., 49° 29′ W., about 3 miles east of a large berg, on July 18, 1929. The conditions there are listed below and are a bit more extreme than the average, but still they are rather typical of the melting conditions that surround nearly all the bergs that melt south of the forty-fourth parallel during the last half of the ice-patrol season.

Levels	Temperatures	Salinities
	°F.	*Per mille*
Surface	57.2	32.89
25 meters	39.7	33.31
50 meters	35.4	33.91
125 meters	37.0	34.42

It is evident from an inspection of the above figures that the berg because of the increasing salinity with depth, would be forced to chill the surface waters very much more than 21.8° F. in order to sink them down to the 50-meter level. The inevitable freshening of the waters while they are being chilled by the glacial ice would make it still harder for them to be sunk.

Let us neglect the great differences of salinities and the freshening effects and assume that the berg will chill the surface waters in immediate contact with it 20° F. and sink them to some depth located between the surface and 50 meters where they will find their new hydrostatic level. It is easy to calculate the approximate amount of water that can be chilled 20° F. by an individual berg of 130,000 short tons mass. Lieut. Commander Edward H. Smith estimates this to be the size of the average berg about the Grand Banks, so it can safely be taken as the average size of bergs in the southern half of this area south of the forty-fourth parallel.

If each pound of the ice can chill 80 pounds of water 1° F., a 260-million pound berg can chill approximately 1,040 million pounds of water 20° F. At 62½ pounds per cubic foot, the amount of water chilled 20° F. would be 16,640,000 cubic feet. Suppose the berg lasts out a full life-expectancy for surface water over 50° F. and continues to melt for 10 days. It will then sink daily, on the average, 1,664,000 cubic feet of water chilled 20° F.

Assuming that the sinking action attracts in toward the berg the surrounding surface waters down to the 10-foot level, what will be the rate of inflow of these surface layers? At the circumference of a circle of 1,000-foot radius from the center of the waterline plane of the berg the area of a 10-foot vertical section of the surface layers of water will be 62,832 square feet. A horizontal inflow of but 27 feet per day, which is only about 0.0002 knot, will more than suffice to supply 1,664,000 cubic feet of water daily through an opening of this size. By proportion it can be assumed that the inflow will amount to about 270 feet per day, or 0.002 knot, at a point close to the ice walls, but 100 feet from the center of the waterline plane of the berg.

The above figures are believed to give a very fair theoretical value for the order of magnitude of surface inflow that is possible about a berg melting in the Grand Banks region. The inflow is undoubtedly so small in value that differential drift of surface and subsurface layers, wind and wave effects, and other confusing elements, are easily capable of distorting and entirely masking most of the noticeable effects of such an inflow, if and when it exists. Even should the above approximations be in error by a factor of 10, still the inflow toward the most rapidly melting bergs would be extremely small.

It is now plain why growlers calved while breezes of any appreciable strength are blowing generally float away rapidly to leeward from a berg. Even those produced during periods of light airs and calms almost invariably move away, though on the average at much lower rates of speed. The maximum flow that the sinking of chilled water can cause apparently produces an inflow of surface water so small that it is nearly always masked by the other forces operating. If the inflow were at all large it would often be able to hold calved growlers and small pieces in positions alongside the parent berg.

Final conclusions regarding the local circulation, both vertical and horizontal, about bergs south of latitude 44° or 48° N. should not be drawn from theoretical considerations, however. Neither should they be formed from the results of a study of tank experiments or of the few actual observations about bergs that have been made to date. It is hoped that when opportunity offers the ice patrol will take numerous special oceanographic stations and make studies with variously colored stains placed in the water close to bergs during all sorts of weather and water conditions. What is now needed is a larger body of exact observational data upon which to base sound opinions.

Microthermographs have been suggested as instruments for warning ships of the proximity of ice during times of low visibility, but whether they will ever be of much practical value is still an open question and subject to grave doubt. The scientific observer of the international ice patrol should never be satisfied until after the detailed

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circulation about bergs under all conditions has been thoroughly investigated and is well understood.

7. MISCELLANEOUS

Detailed sounding and bottom sampling work about the Grand Banks region would be very useful, practically as well as scientifically. For the past five centuries the fishermen of France have been frequenting this area, yet even to-day the French scientists admit that they know almost nothing about the composition or detailed bottom configuration of the top or slopes of the Grand Banks plateau. Steam trawlers are annually increasing in numbers there. These vessels can not proceed haphazardly with their fishing like the old fashioned sailing vessels. Their costs prohibit hit or miss methods. They must know promptly where the greatest numbers of fish are located and where the bottom characteristics are not destructive to their expensive gear. Well coordinated scientific investigations are called for by the fisheries problems alone.

In 1927 one of the French Government ships attending the fishing fleet reported that three new shoals were situated less than 30 miles to the westward of the main track of bergs along the 1,000-fathom curve of the eastern slope of the Grand Banks. These shoals, though small, were said to have only 8 to 11 fathoms of water over them. Do they presage the birth of another low sandy island like that graveyard of the Atlantic, Sable Island, or will the water over them eventually be deepened by the waves of the open sea? Only continued soundings in their vicinity can tell.

On November 18, 1929, there occurred an earthquake centered in the sea south of Newfoundland. The shock was severe enough to be distinctly felt in the New England States, over 800 miles to the westward. Twelve cables crossing the area of greatest disturbance were broken in 23 places and the Burin Peninsula of Southern Newfoundland was visited by an earthquake wave. This wave was so large that much property and a number of lives were destroyed. Some geologists believe that the section of the ocean floor where the cable breaks occurred foundered during this earthquake. The ice-patrol ships will have a good opportunity to sound out the supposedly sunken area south-southeast of Cabot Strait with sonic depth finders, for they must cross it every time they proceed between the ice regions and their Nova Scotian base of supplies. If any great increase in depth over the form values exists, it should be detected when the new soundings are compared with the old ones that are already on the charts.

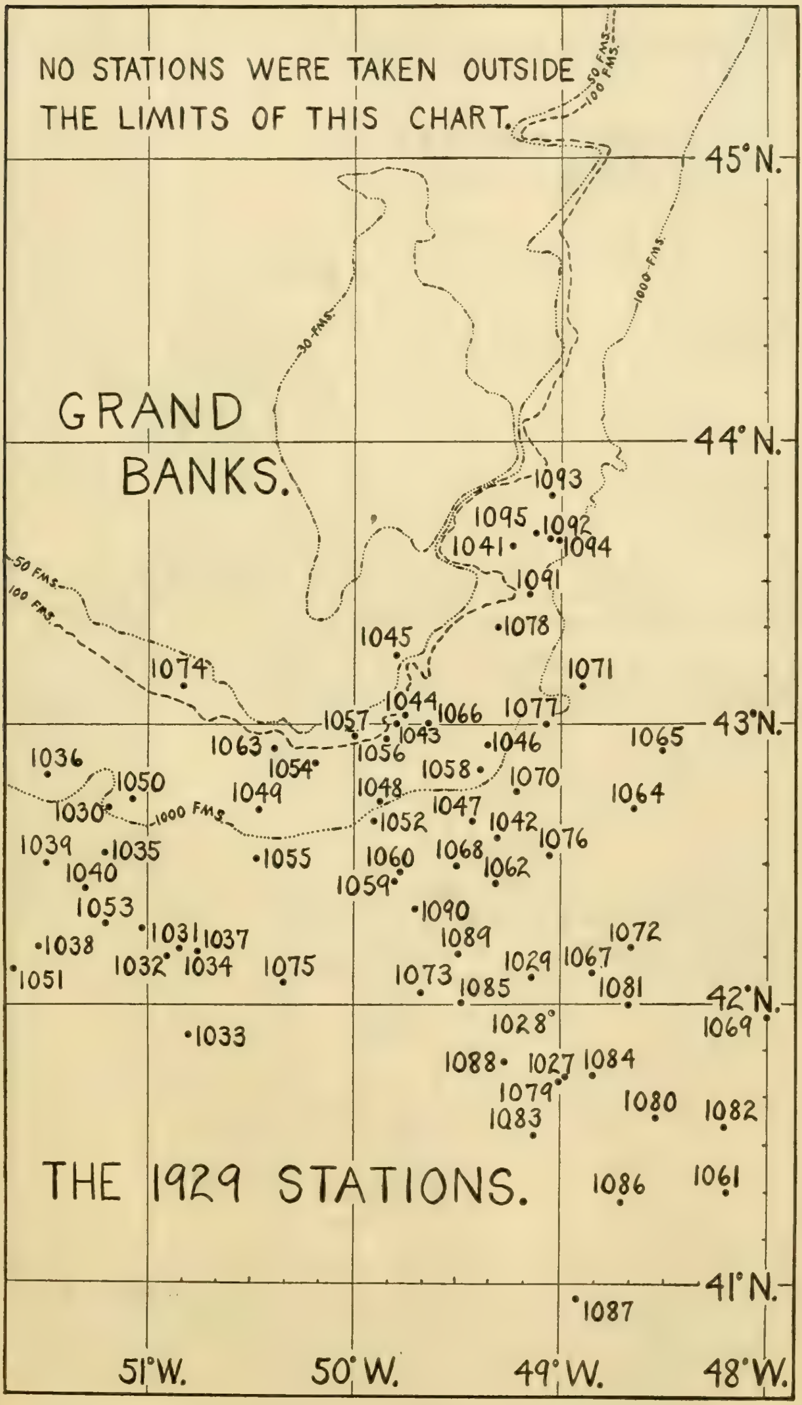
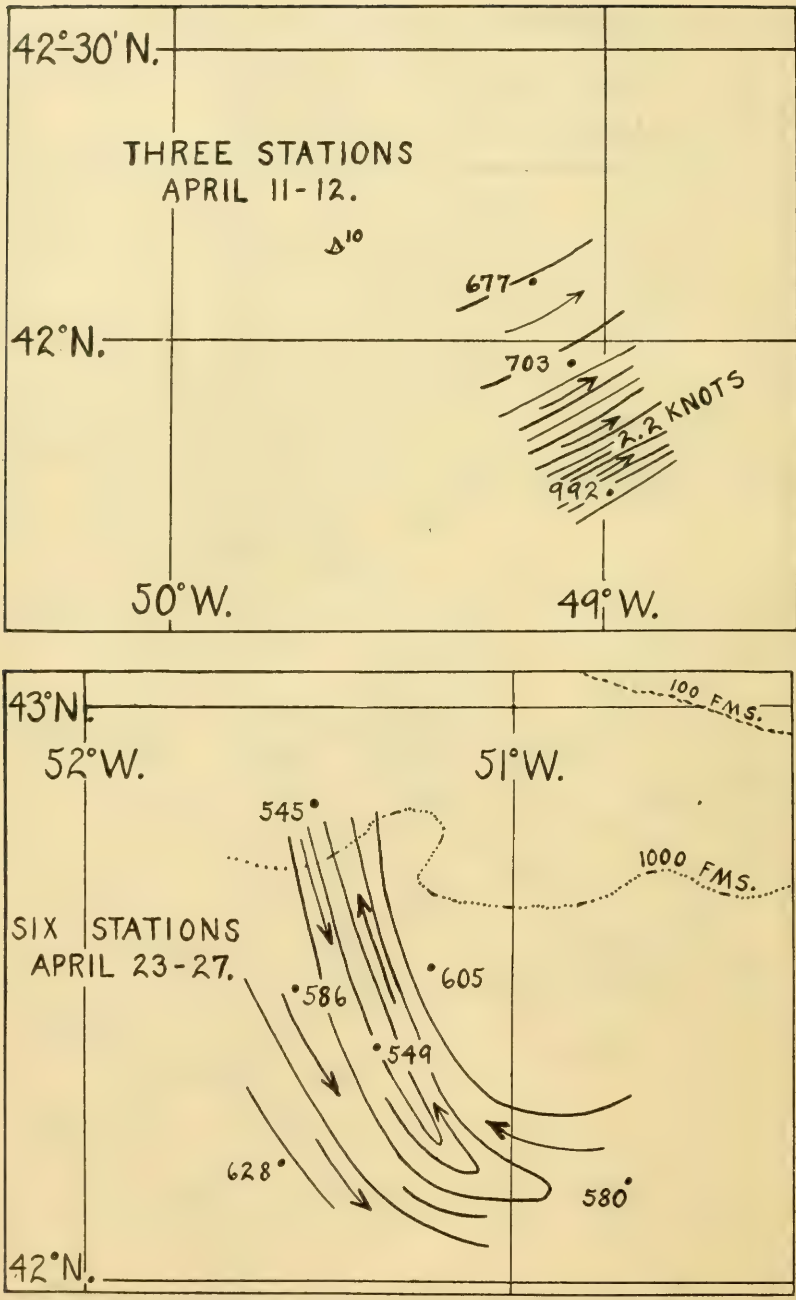


FIGURE 12.—Distribution of oceanographic stations



FIGURES 13 AND 14.—Two current maps constructed from two small groups of stations occupied during April, 1929. Three-figure numbers near stations show in dynamic millimeters distance in excess of 728 dynamic meters from sea surface to 750-decibar pressure level; 2.2-knot current indicated between two southeasternmost stations was computed from formulas in Coast Guard Bulletin No. 14. Currents of this magnitude are frequently experienced in reality near the temperature wall between Gulf Stream and Labrador Current waters

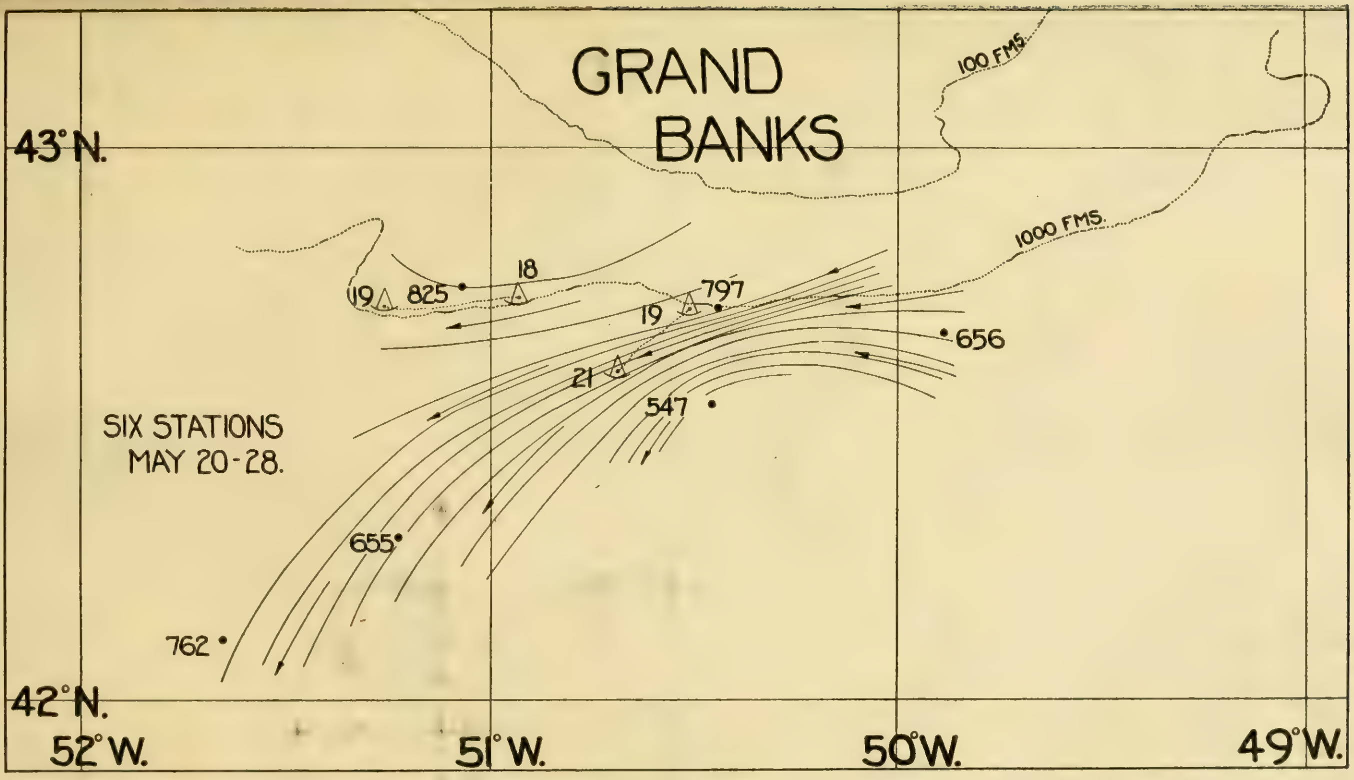


FIGURE 15.—Current map made from a group of stations occupied during May, 1929. Three-figure numbers near stations show in dynamic millimeters distance in excess of 728 dynamic meters from sea surface to 750-decibar pressure level. Great packing of contour lines between the two stations SSW. of the Tail probably due in part to the 8-day interval between their dates of occupation. At no time during May was a current of unusual strength observed in this locality

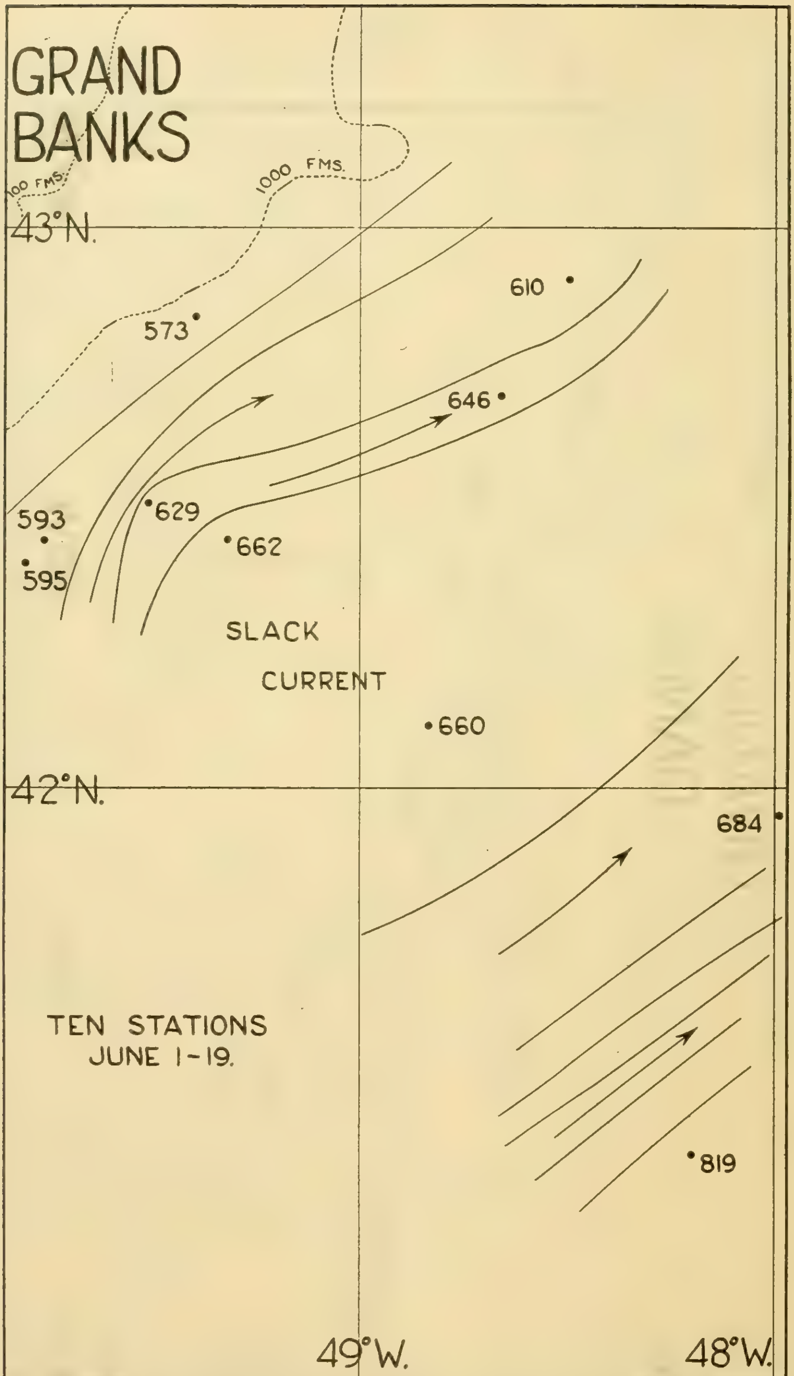


FIGURE 16.—Current map made from a group of stations occupied during June, 1929. The 3-figure numbers near stations show in dynamic millimeters the distance in excess of 728 dynamic meters from sea surface to 750-decibar pressure level. It appears from this map that two bands of current setting northeastward existed southeast of the Banks with an almost currentless area between them. Such slack waters do exist in fact off the Banks at times and bergs getting into them may remain almost stationary for several days

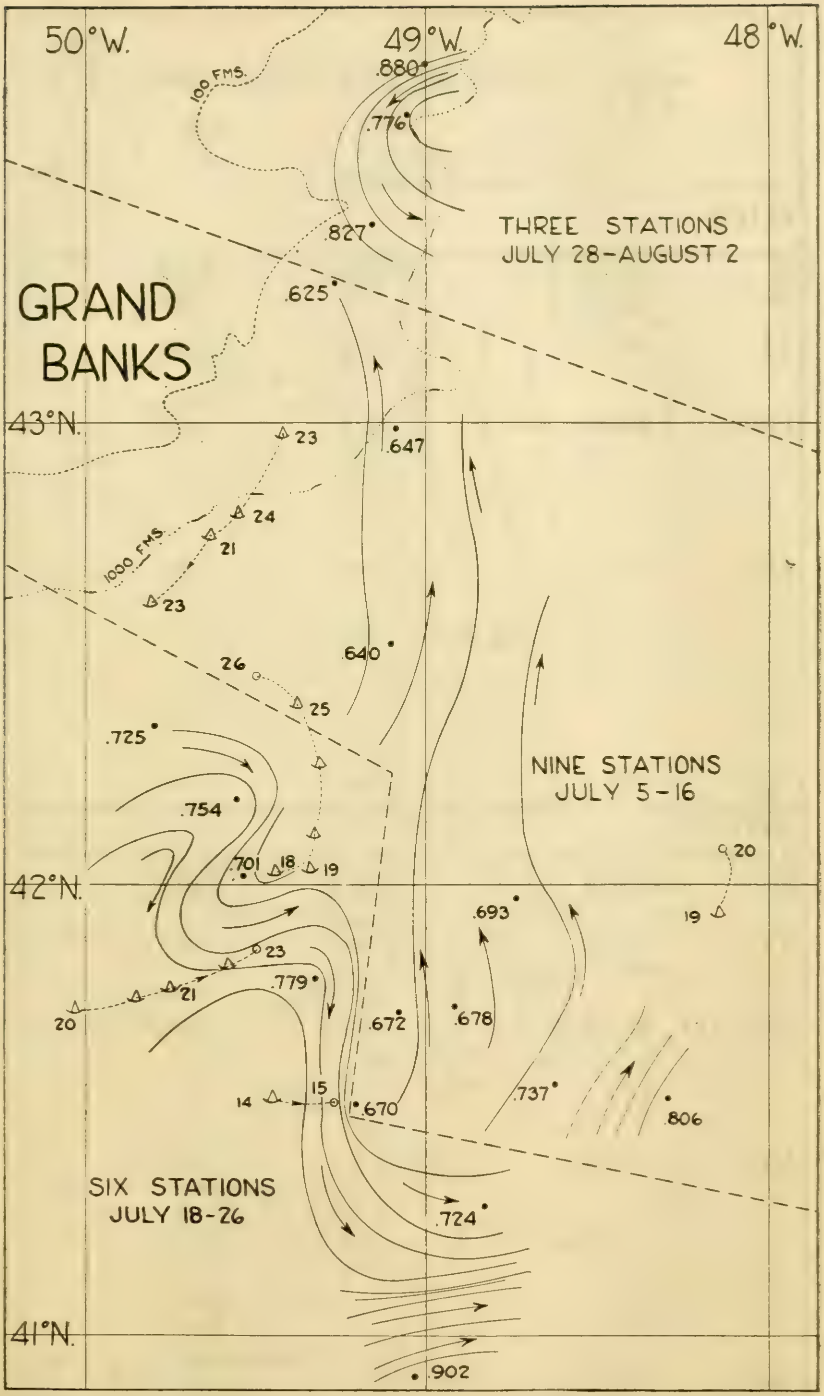


FIGURE 17.—Current map constructed from small groups of late season stations. Dashed lines show areas that are to be considered separately because of time-lapse factor. Three-figure numbers near stations show in dynamic millimeters distance in excess of 728 dynamic meters from sea surface to 750-decibar pressure level. A few known berg drifts are plotted to show relation between actual and dynamically determined currents

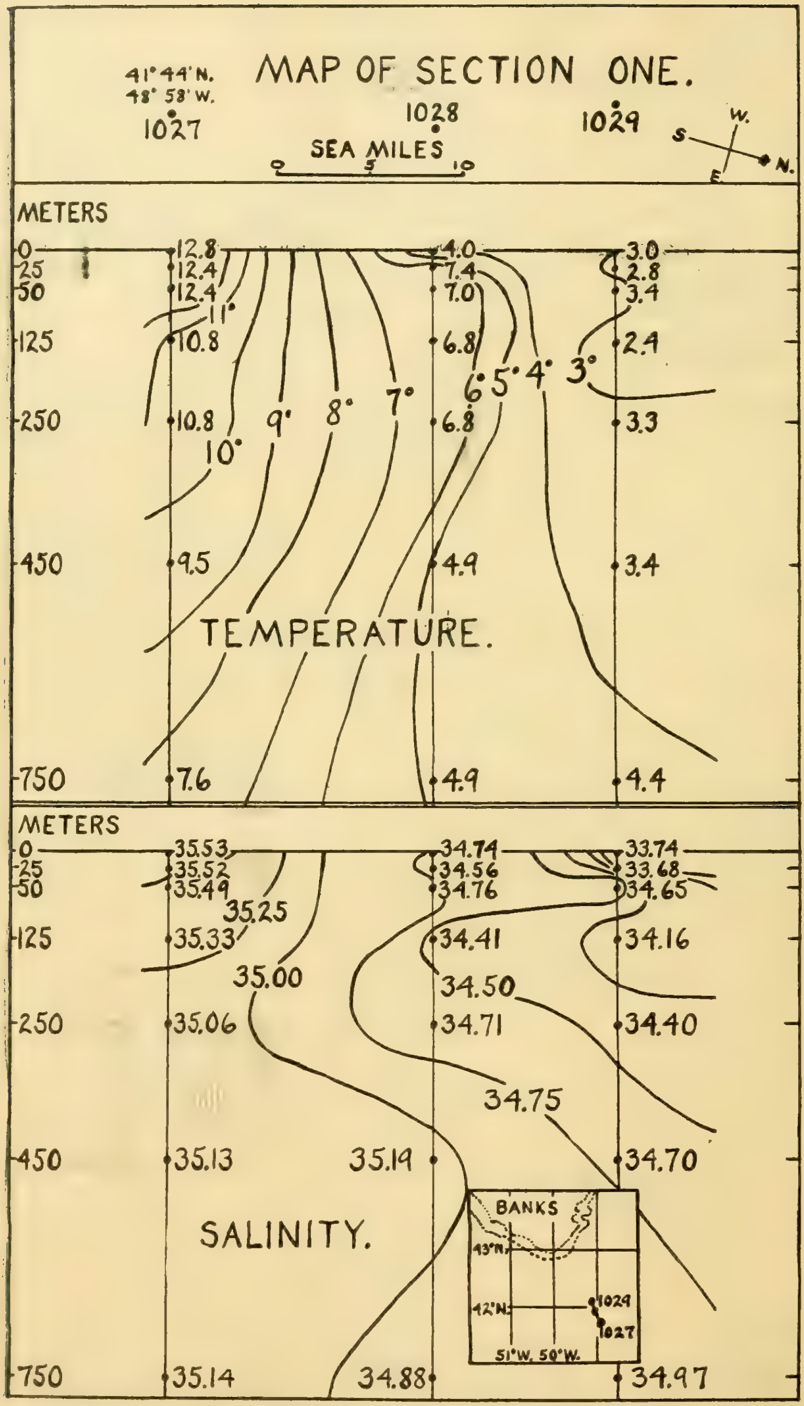


FIGURE 18.—Oceanographic section one was drawn from data obtained at stations taken April 11–12, 1929. The vertical scale is exaggerated about sixty times. Note very steep slope of isotherms and isohalines, characteristic of temperature wall

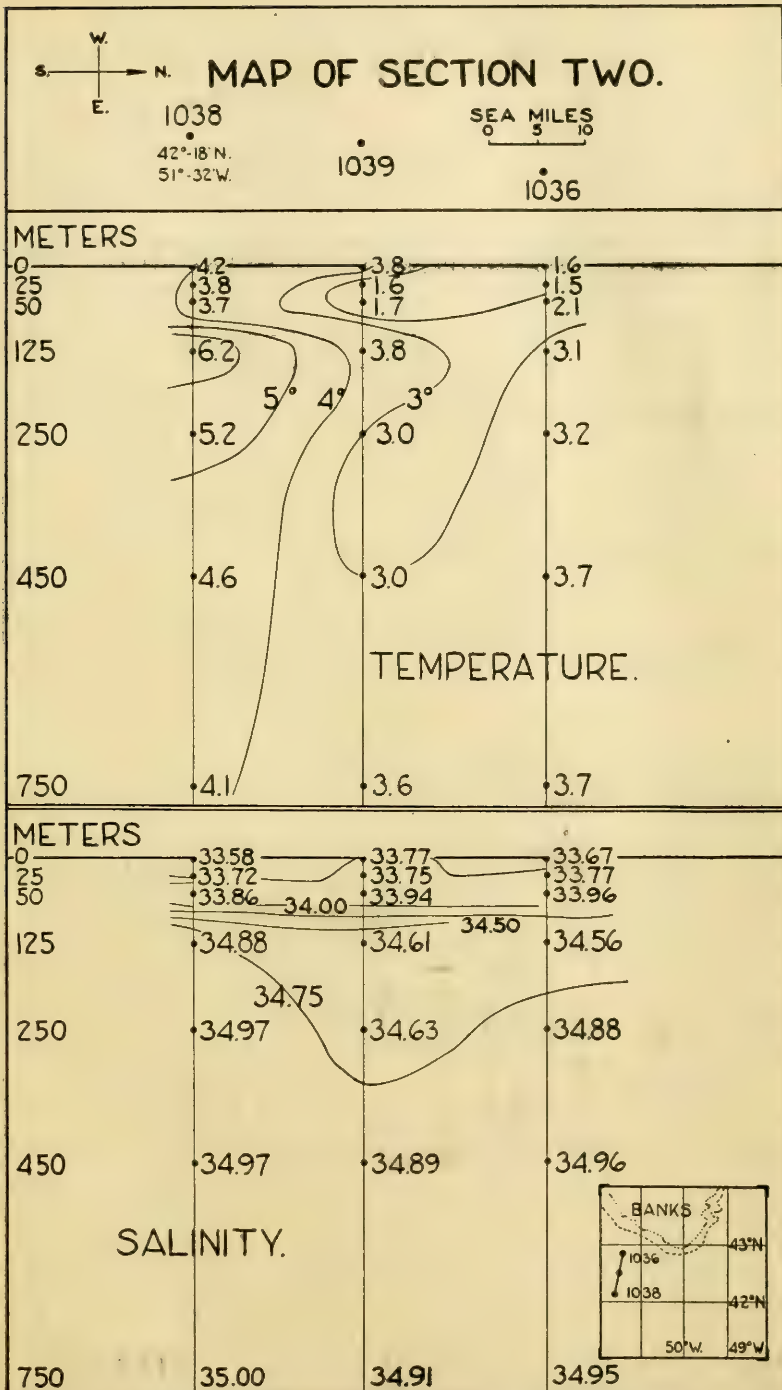


FIGURE 19.—Oceanographic section two was drawn from data obtained at stations taken April 23–26, 1929. The vertical scale is exaggerated about one hundred and twenty times. The salinity increases markedly with depth. This is characteristic of the cold and mixed waters about the Tail, where the Labrador Current overrides warmer Atlantic water of higher salinity

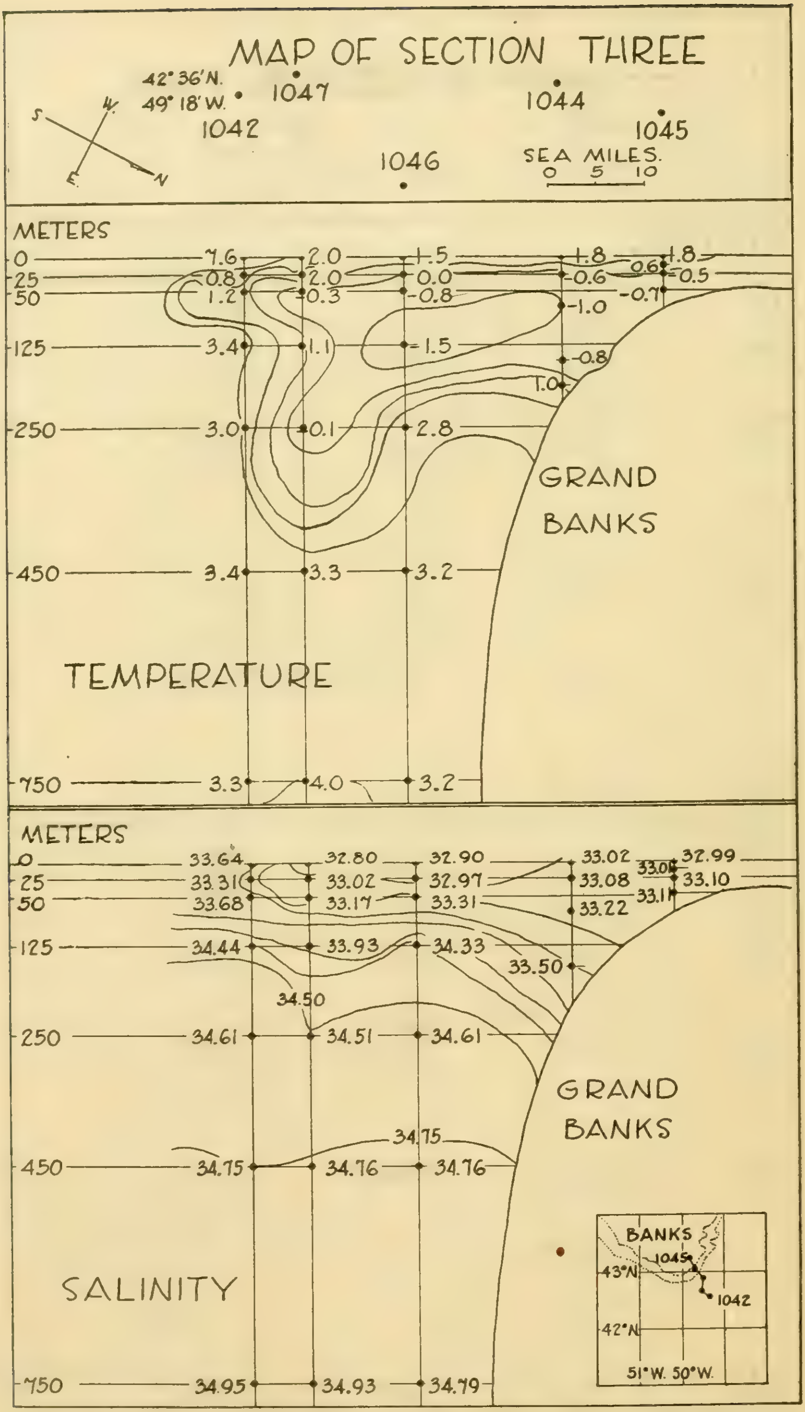


FIGURE 20.—Oceanographic section three was drawn from data obtained at stations taken May 6–11, 1929. The vertical scale is exaggerated about one hundred and twenty times. The salinity increases rapidly with depth. A cold-water layer between warmer surface and bottom waters can be seen. This is characteristic of the Labrador Current after the sun warms up the surface layers in the spring

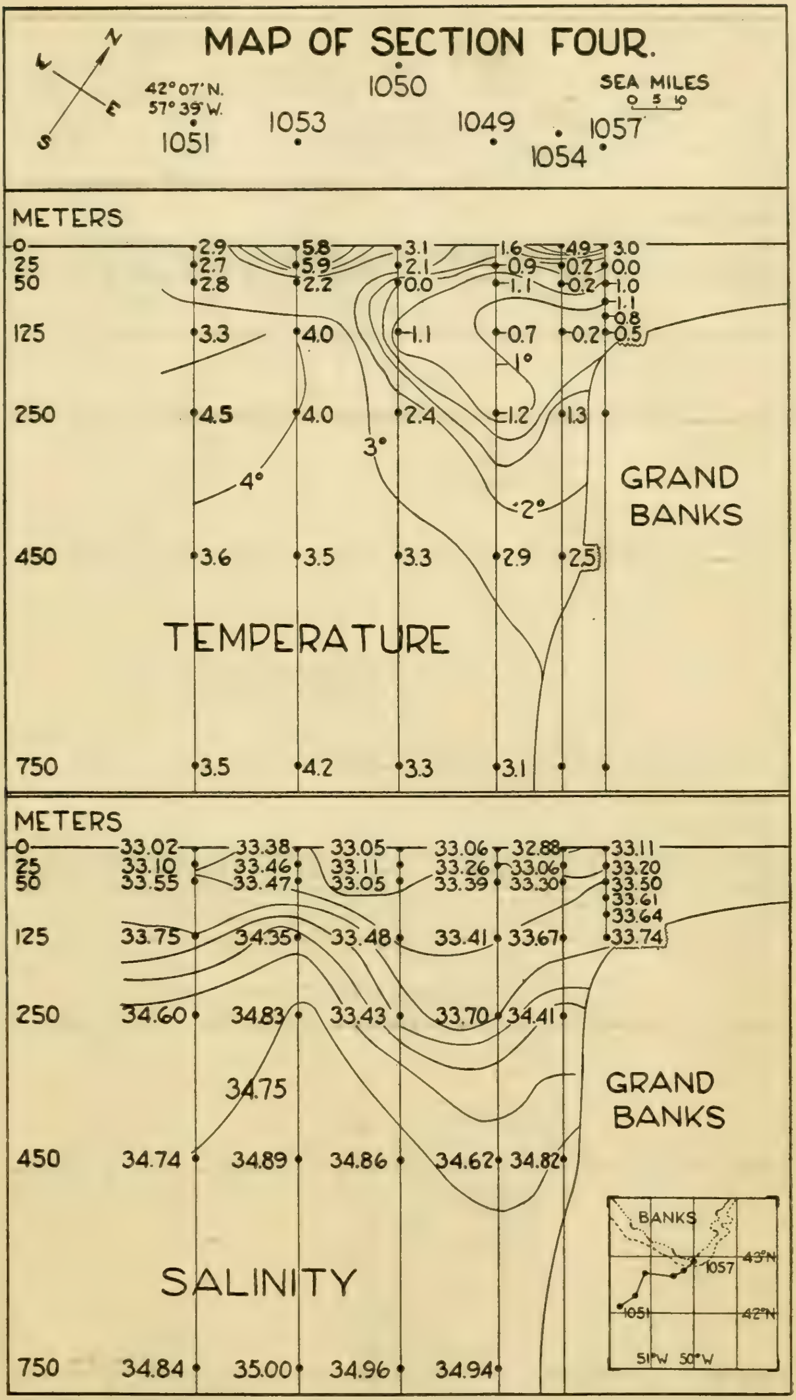


FIGURE 21.—Oceanographic section four was drawn from data obtained at stations taken May 20–31, 1929. Vertical scale exaggerated about two hundred and forty times. Temperature and salinity distribution similar to that of section three

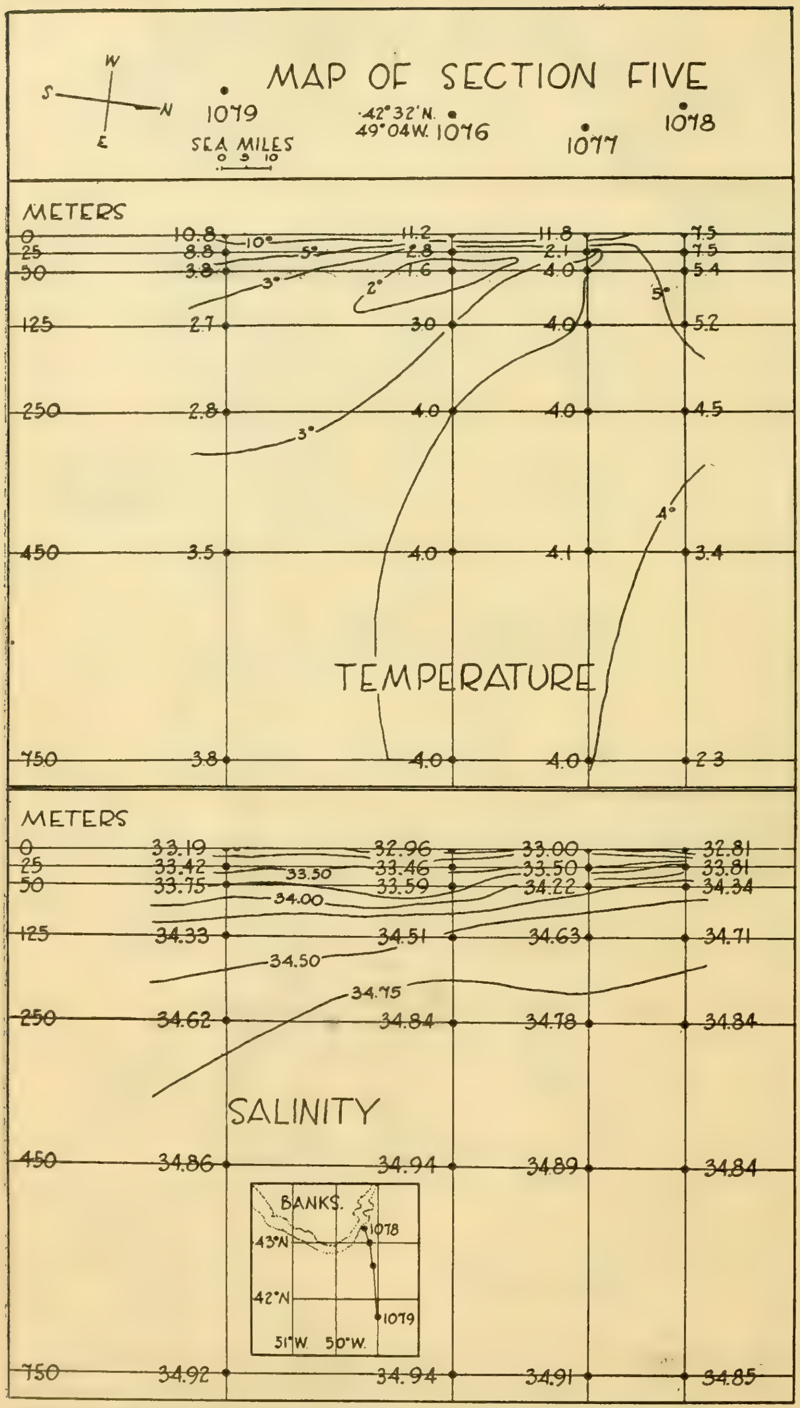


FIGURE 22.—Oceanographic section five was drawn from data obtained at stations taken July 5–8, 1929. Vertical scale exaggerated about two hundred and forty times. Temperature and salinity distribution similar to that of section six

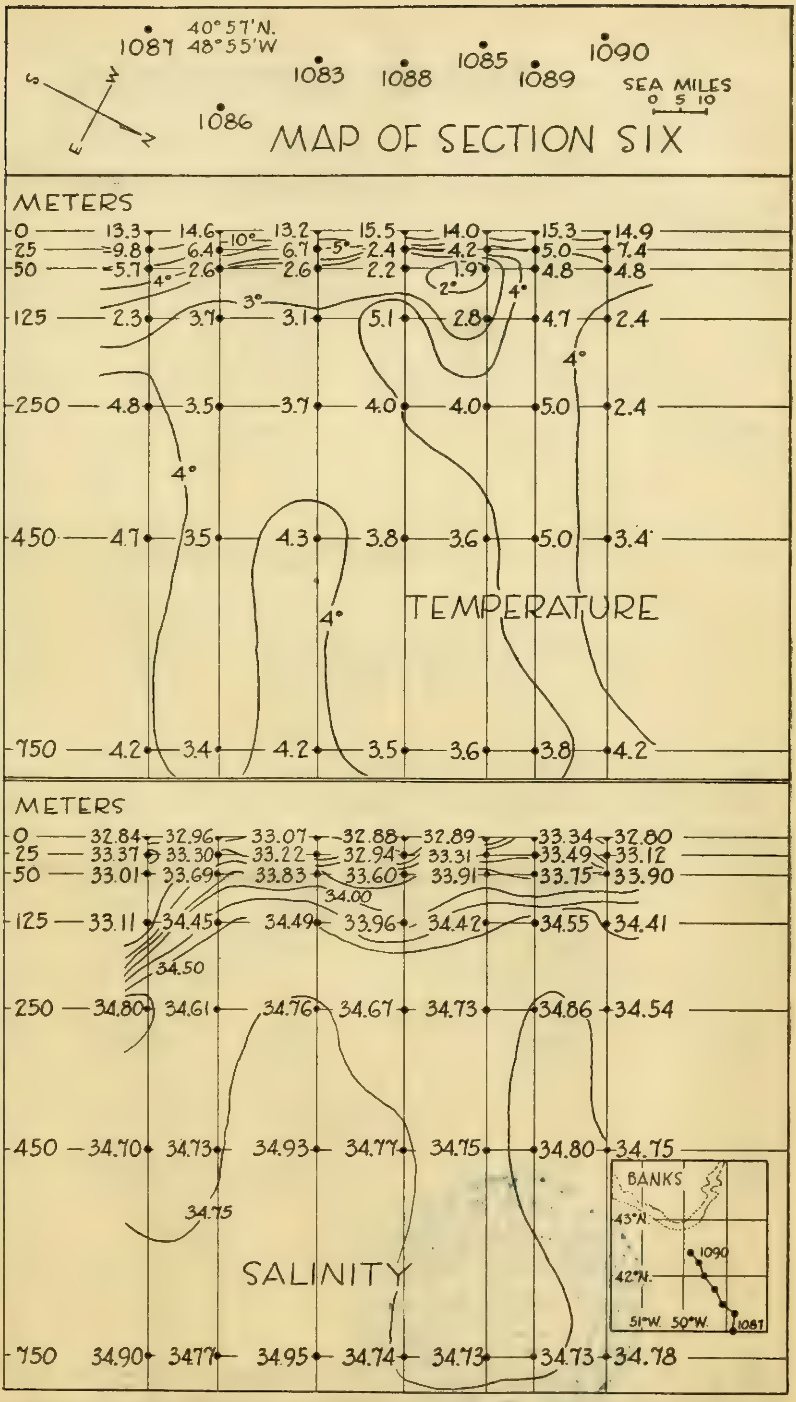


FIGURE 23.—Oceanographic section six was drawn from data obtained at stations taken July 15–26, 1929. Vertical scale exaggerated about two hundred and forty times. Surface layers much warmed. Salinity increases rapidly from surface to 200-meter level due to push of Labrador Current over North Atlantic mid-depth and bottom waters

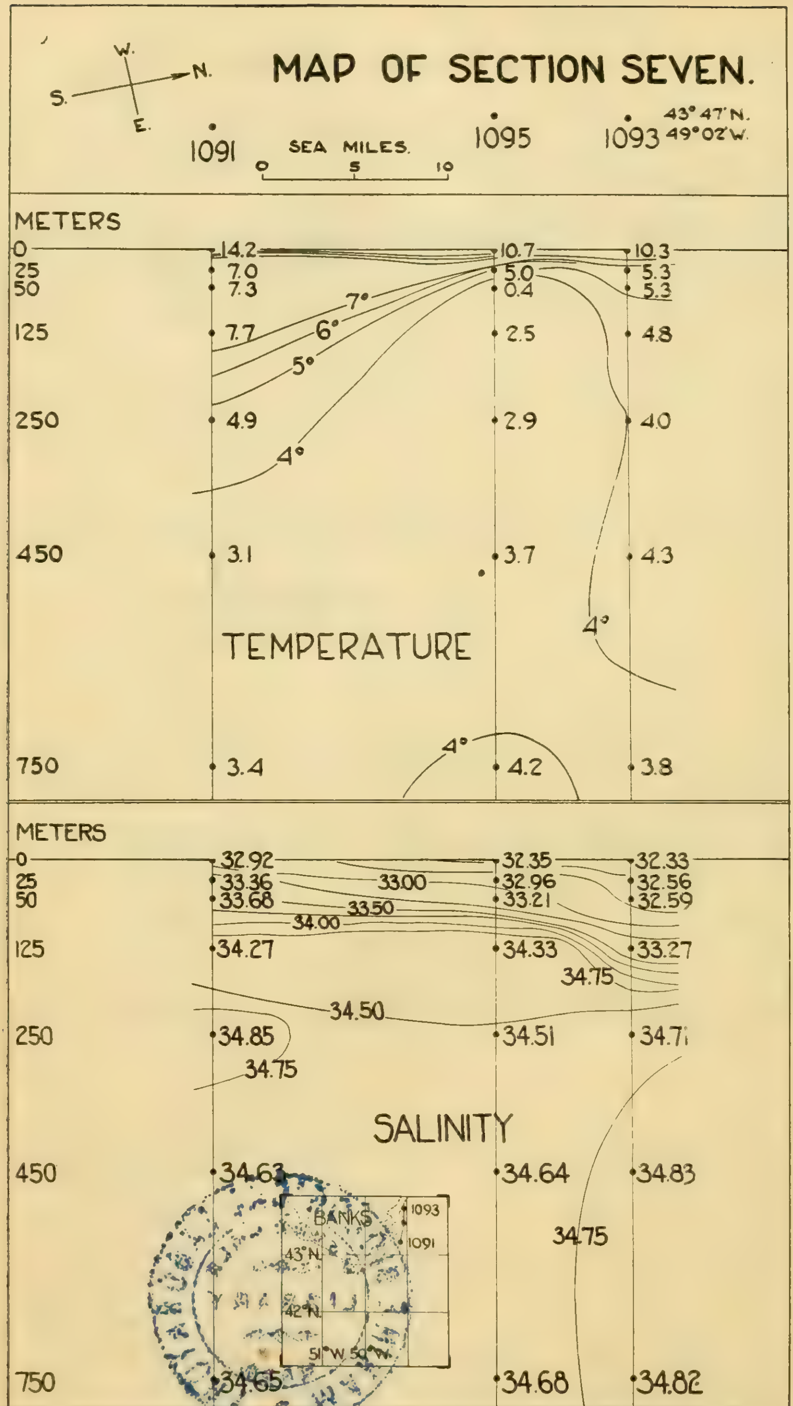


FIGURE 24.—Oceanographic section seven was drawn from data obtained at stations taken July 28 to August 2, 1929. Vertical scale exaggerated about sixty times. Temperature and salinity distribution similar to that of section six

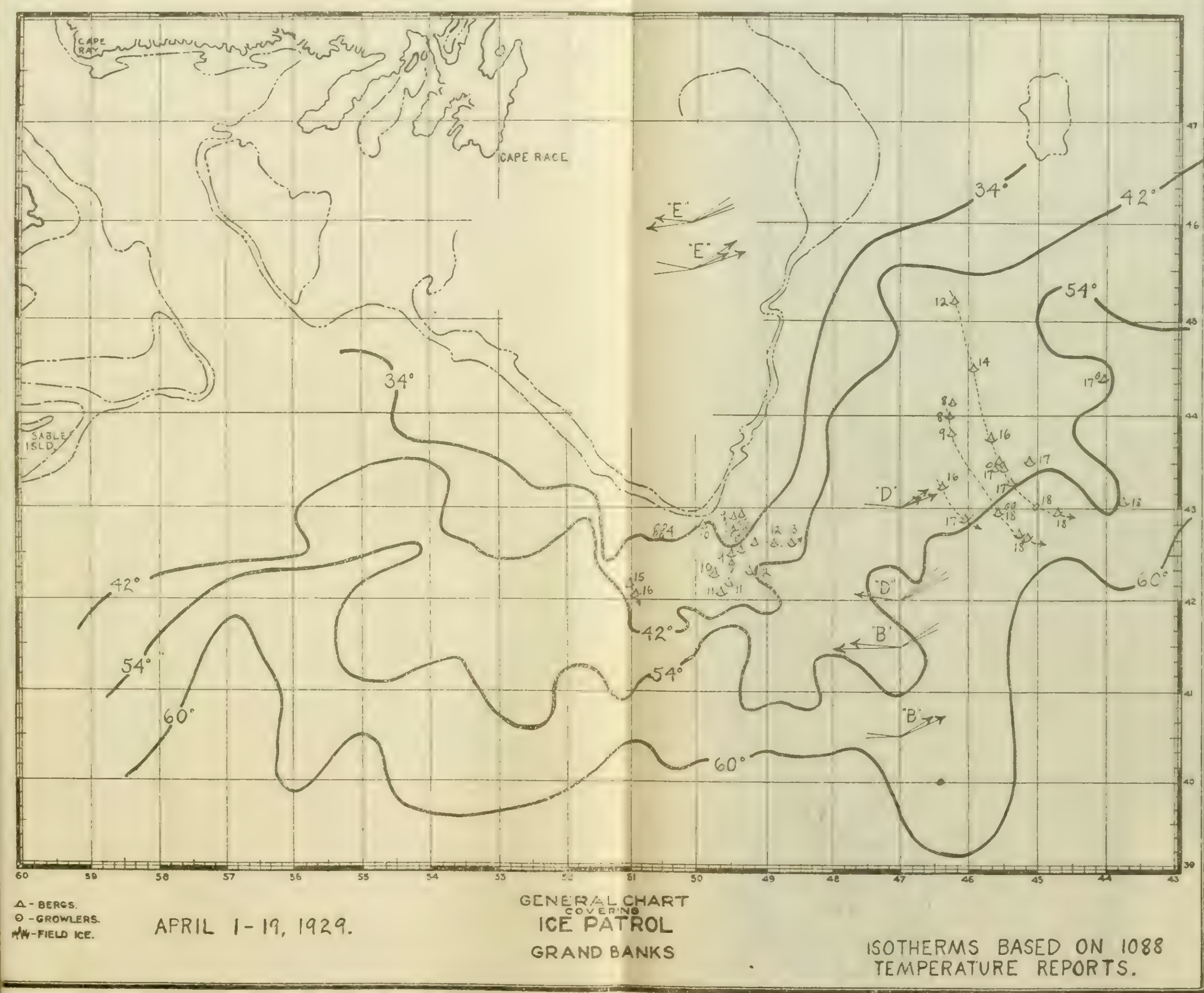


FIGURE [illegible].—Surface temperatures April 1-19, 1929. Portions of steamship tracks in use and southernmost ice are shown. Dotted lines connecting berg positions indicate probable drift tracks.

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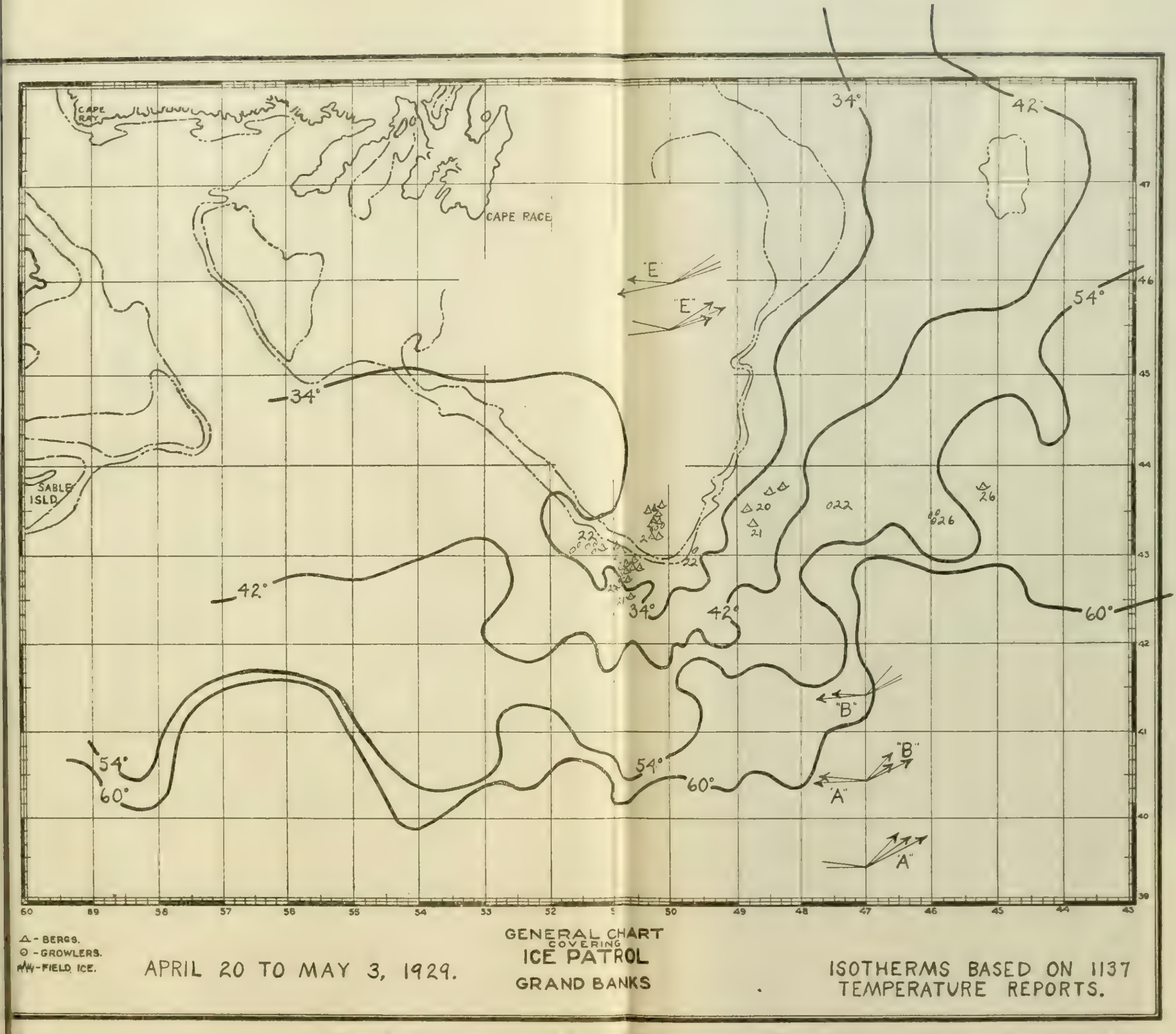

FIGURE 26.—Surface temperatures April 20 to May 3, 1929. See remarks under Figure 25

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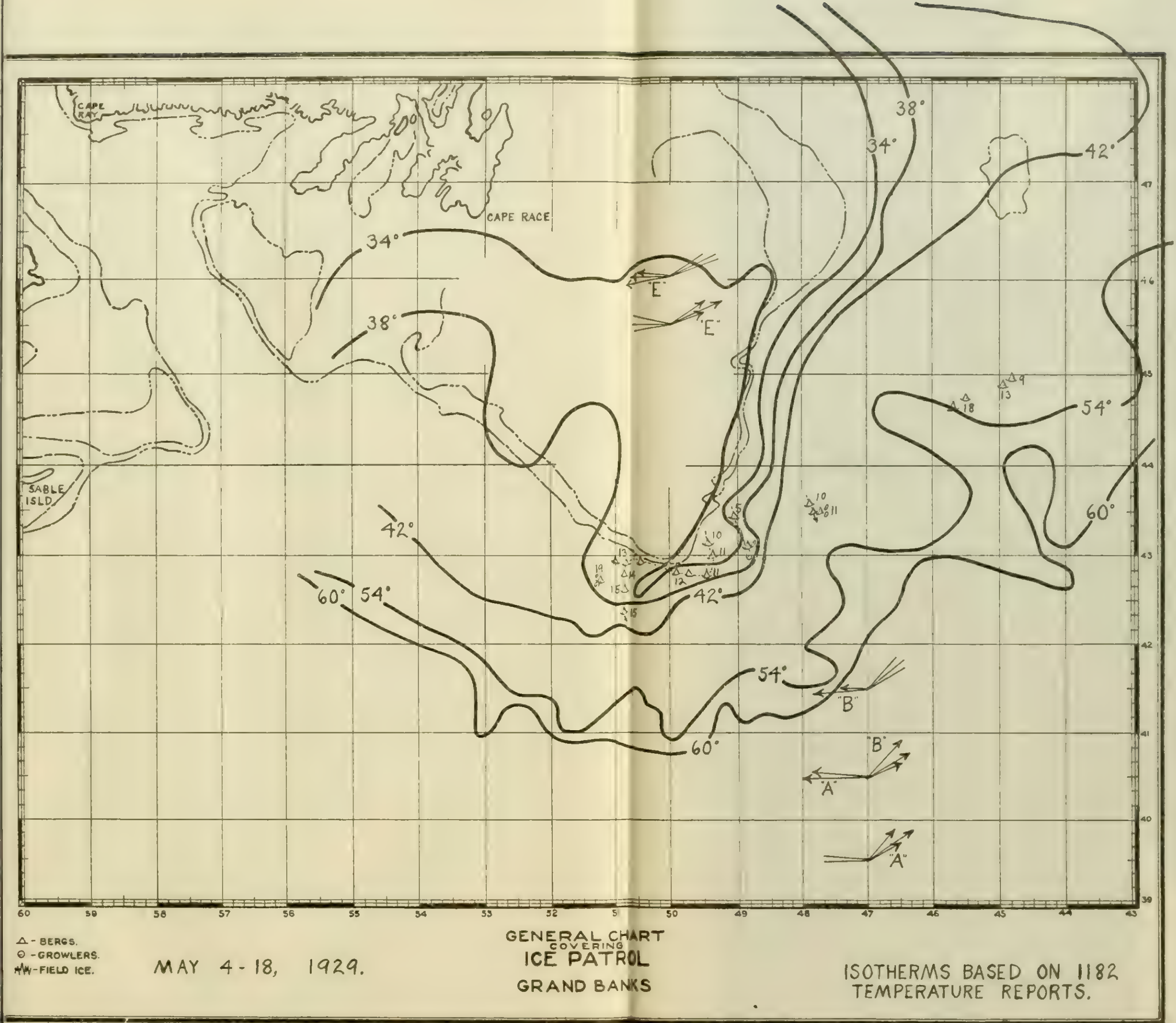

FIGURE 27.—Surface temperatures May 4-18, 1929. See remarks under Figure 25

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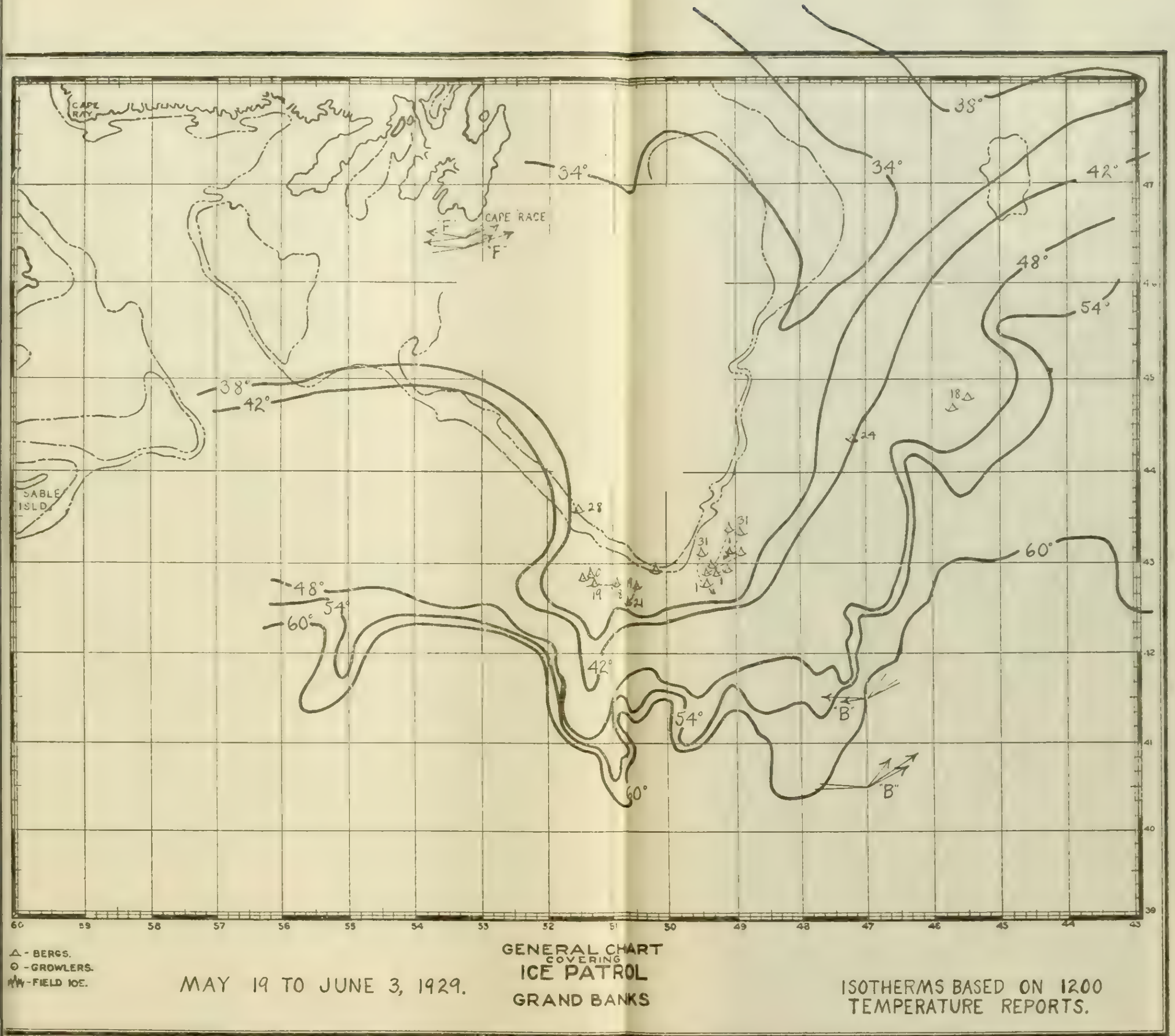

FIGURE 28.—Surface temperatures May 19 to June 3, 1929. See remarks under Figure 25

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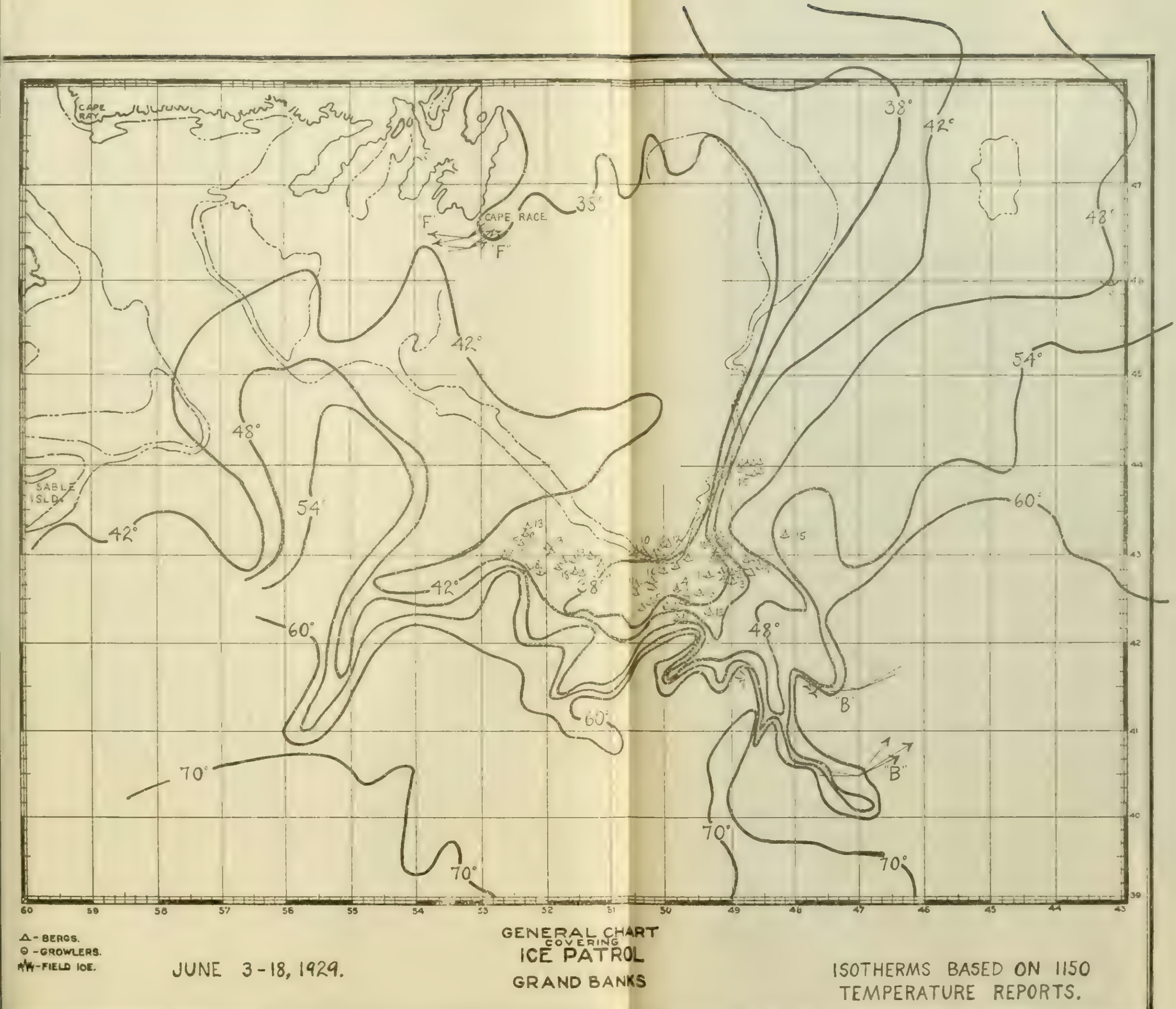

FIGURE 29. Surface temperatures June 3-18, 1929. See remarks under Figure 25

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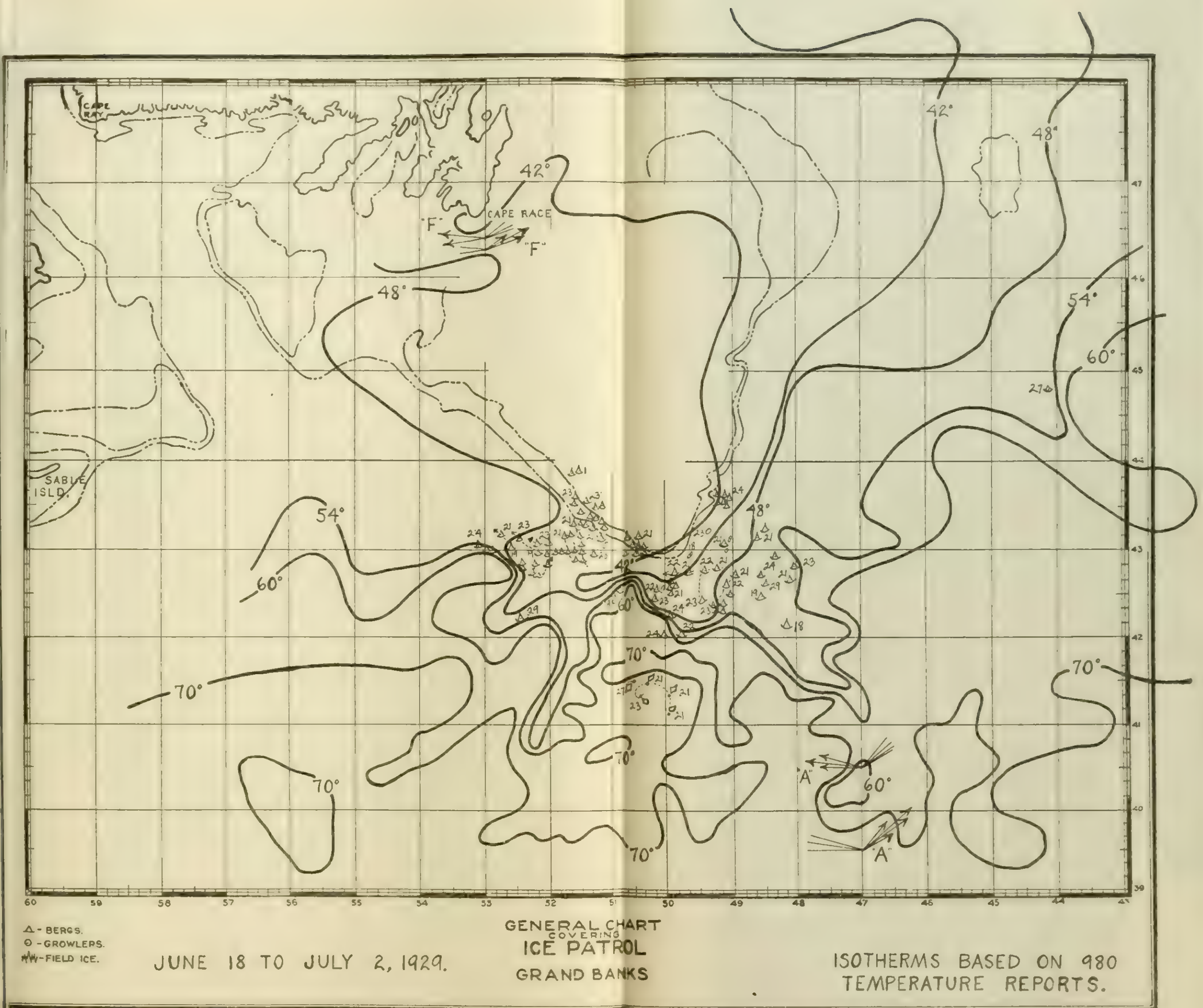

FIGURE 30.—Surface temperatures June 18 to July 2, 1929. See remarks under Figure 25

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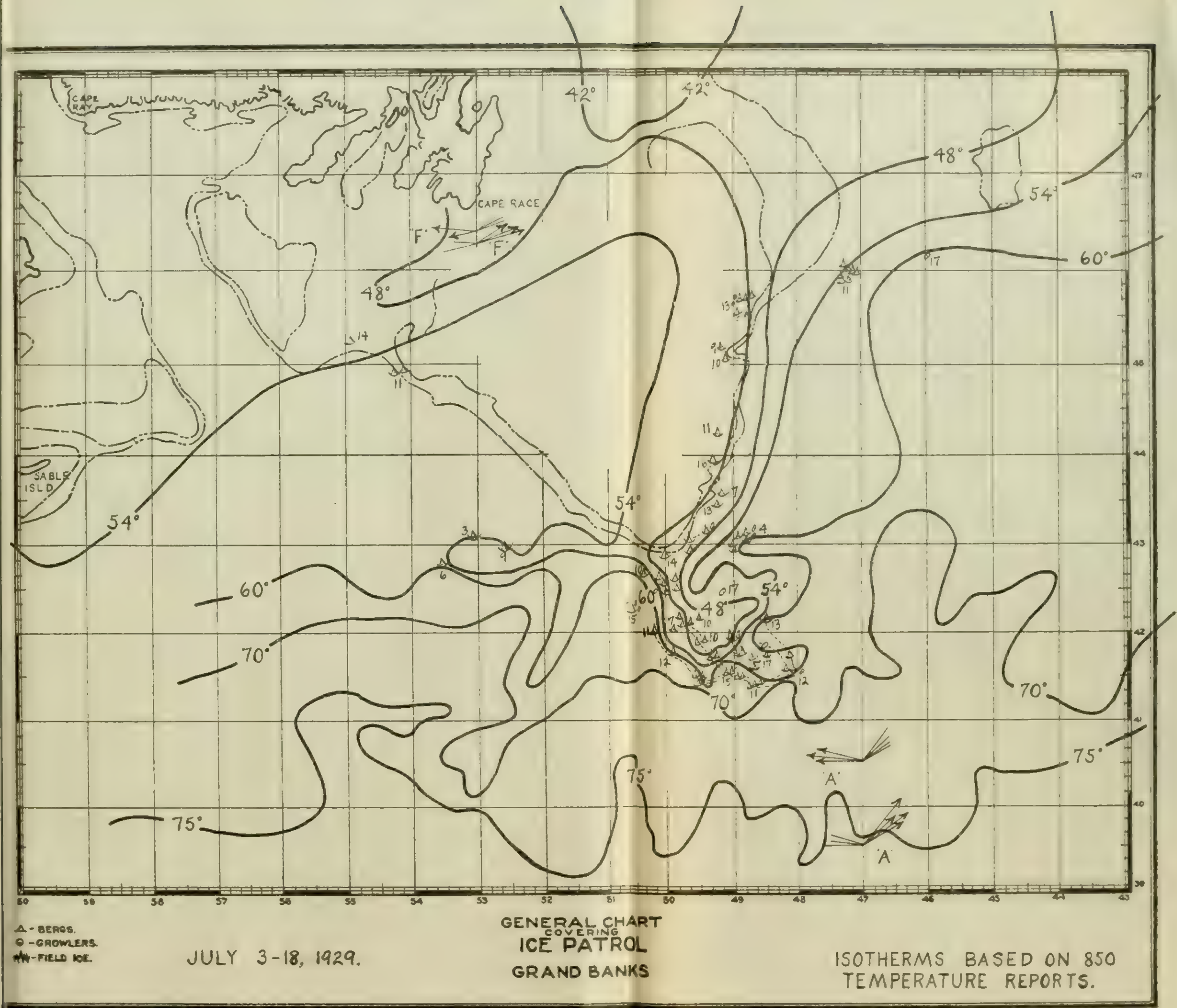

FIGURE 31.—Surface temperatures July 3-18, 1929. See remarks under Figure 25

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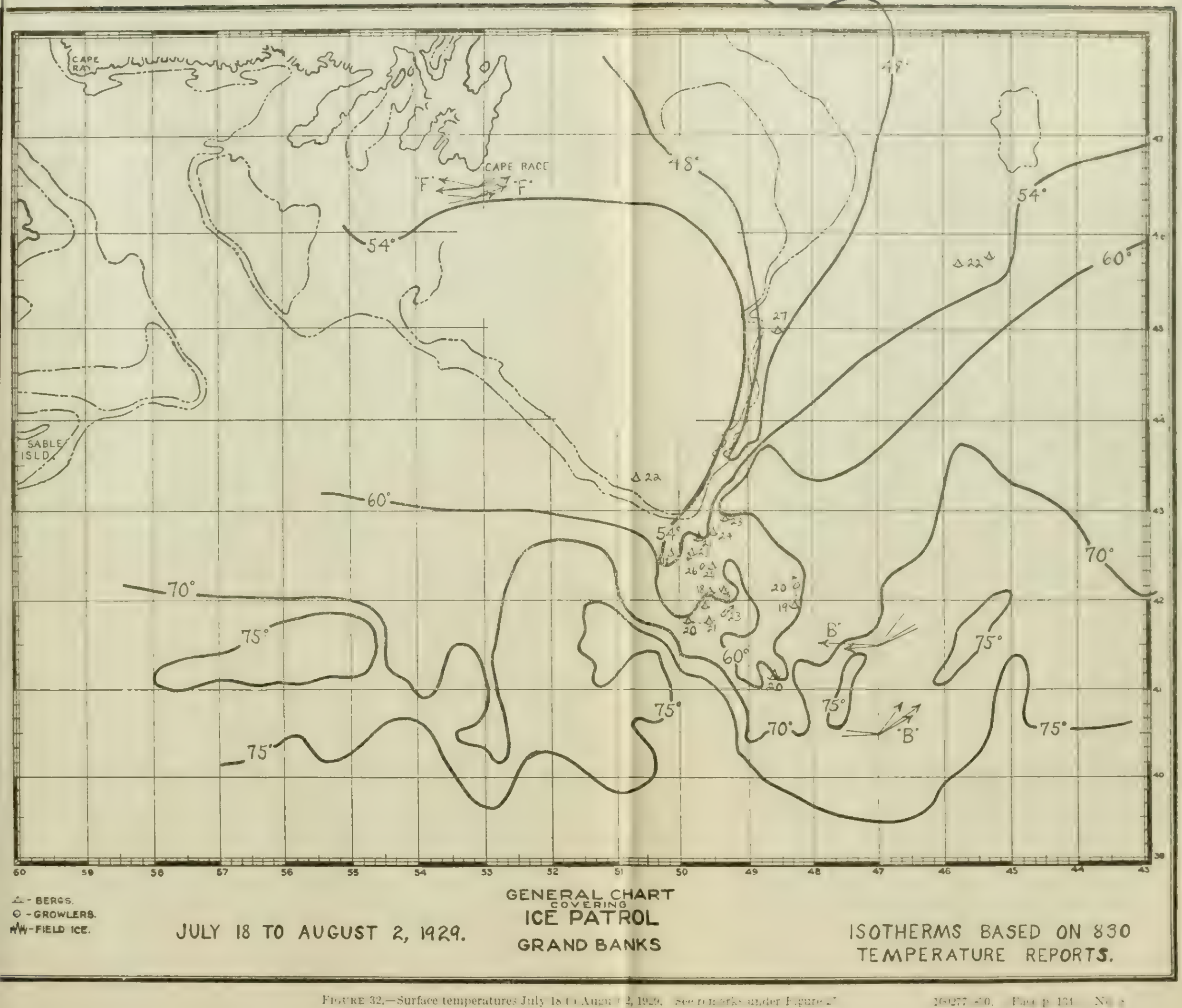

FIGURE 32.—Surface temperatures July 18 to August 2, 1929. See remarks under Figure 2[illegible]

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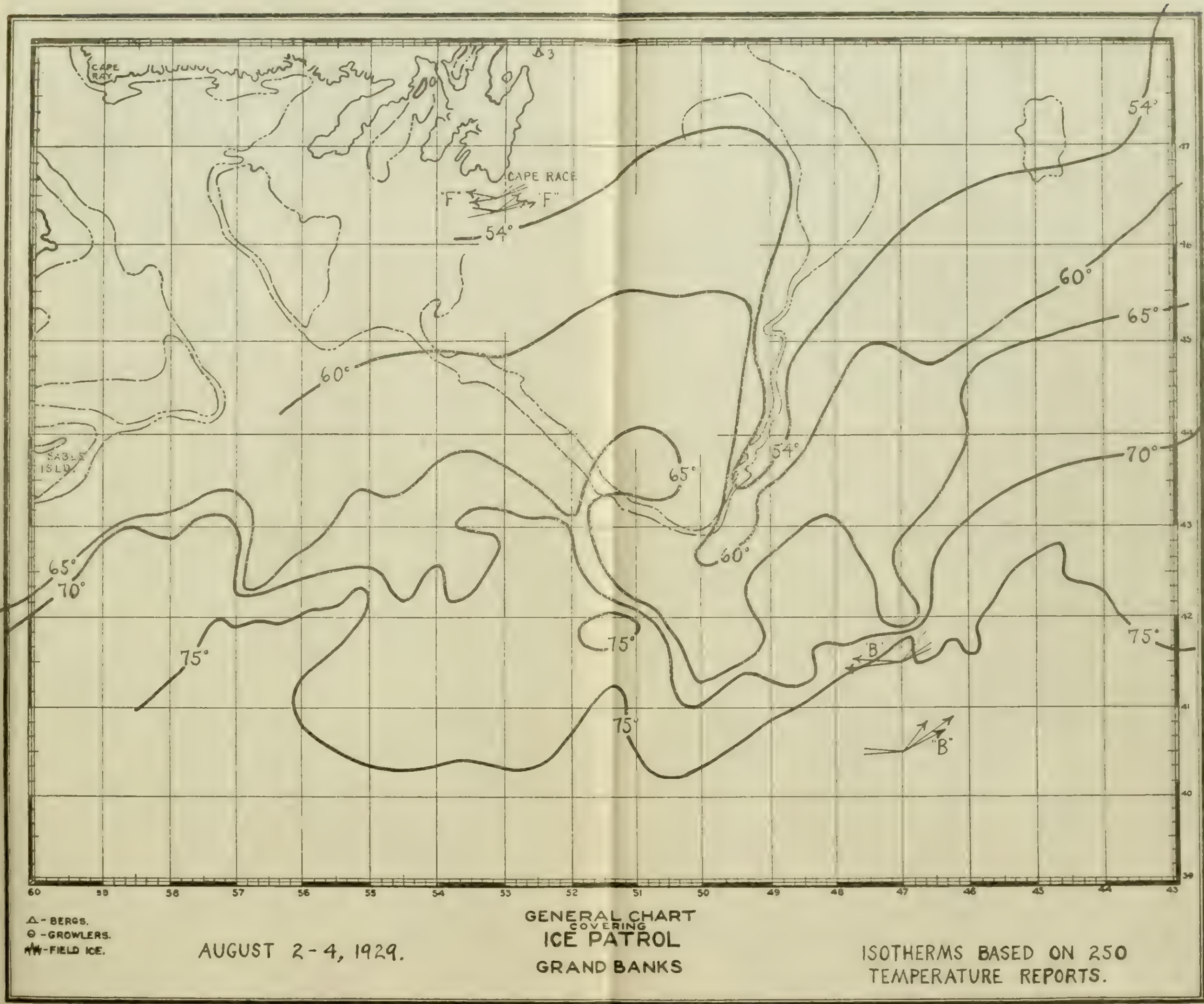

FIGURE 33.—Surface temperatures August 2-4, 1929. Only one iceberg reported during this period south of 48th parallel

OCEANOGRAPHIC STATION DATA AND DYNAMIC CALCULATIONS
1929

δ_t at head of column 9 represents the value, density.
V at head of column 10 represents the value, specific volume in situ.
$V-V_1$ at head of column 11 represents the value, anomaly of specific volume in situ.
E at head of column 12 represents the value, height in dynamic meters.
$E-E_1$ at head of column 13 represents the value, anomaly of dynamic height.

Station	Date	Latitude N.	Longitude W.	a Depth of water	a_1 Depth	a=meters: Temperature	a=meters: Salinity	a=meters: δ_t	a_1=pressure in decibars: V	a_1=pressure in decibars: $V-V_1$	a_1=pressure in decibars: E	a_1=pressure in decibars: $E-E_1$
		° ′	° ′			° C.	0/00					
1027	Apr. 11	41 44	48 58	3, 109	0	12.8	35.53	26.86	0.97384	120	0	0
					25	12.4	35.52	26.93	.97366	113	24.34375	.02910
					50	12.4	35.49	26.91	.97357	115	48.68413	.05763
					125	10.8	35.33	27.08	.97310	102	121.68425	.13913
					250	10.8	35.06	26.88	.97275	123	243.29988	.27989
					450	9.5	35.13	27.16	.97164	102	437.73888	.50539
					750	7.6	35.14	27.46	.97005	76	728.99238	.77289
1028	---do----	41 58	49 03	3, 229	0	4.0	34.74	27.60	.97314	50	0	0
					25	7.4	34.56	27.04	.97356	103	24.33375	.01910
					50	7.0	34.76	27.25	.97325	83	48.66888	.04238
					125	6.8	34.41	27.01	.97316	108	121.65925	.11413
					250	6.8	34.71	27.24	.97240	88	243.25675	.23676
					450	4.9	35.19	27.87	.97092	30	437.58875	.35526
					750	4.9	34.88	27.63	.96984	55	728.70275	.48326
1029	Apr. 12	42 06	49 09	3, 200	0	3.0	33.74	26.90	.97380	116	0	0
					25	2.8	33.68	26.87	.97372	119	24.34400	.02935
					50	3.4	34.65	27.59	.97292	50	48.67700	.05050
					125	2.4	34.16	27.28	.97290	82	121.64525	.10013
					250	3.3	34.40	27.40	.97222	70	243.21525	.19575
					450	3.4	34.70	27.63	.97112	50	437.54925	.31576
					750	4.4	34.97	27.74	.96973	44	728.67675	.45726
1030	Apr. 14	42 43	51 10	1, 463	0	−.6	33.32	26.80	.97390	126	0	0
					25	[1] −.8	33.33	26.81	.97378	125	24.34613	.03148
					50	−1.0	33.17	26.69	.97377	135	48.69050	.06400
					125	−1.1	33.59	27.03	.97312	104	121.69887	.15375
					250	−1.1	33.28	26.78	.97279	127	243.31824	.29825
					450	0	34.54	27.76	.97097	35	437.69424	.46075
					750	3.5	34.79	27.70	.96975	46	728.80224	.58275
1031	Apr. 15	42 16	51 01	2, 926	0	1.8	33.83	27.07	.97365	101	0	0
					25	1.8	33.86	27.10	.97351	98	24.33950	.02485
					50	2.2	34.22	27.35	.97315	73	48.67275	.04625
					125	3.6	34.62	27.54	.97265	57	121.64025	.09513
					250	−.6	34.12	27.44	.97216	64	243.19087	.17088
					450	0	34.11	27.41	.97130	68	437.53687	.30338
					750	4.2	34.80	27.63	.96982	53	728.70487	.48538
1032	---do-----	42 10	50 55	2, 926	0	3.4	33.78	26.90	.97380	116	0	0
					25	2.5	33.81	27.00	.97360	107	24.34250	.02785
					50	2.5	33.78	26.97	.97351	109	48.68137	.05487
					125	2.0	33.82	27.05	.97311	103	121.68962	.14450
					250	2.0	33.83	27.05	.97255	103	243.28337	.26338
					450	3.2	33.81	26.94	.97177	115	437.71537	.48188
					750	3.4	34.65	27.59	.96985	56	728.95837	.73888
1033	Apr. 16	41 53	50 47	3, 749	0	3.8	33.84	26.91	.97379	115	0	0
					25	3.8	33.82	26.89	.97370	117	24.34350	.02885
					50	3.6	33.87	26.95	.97352	110	48.68375	.05725
					125	4.6	34.38	27.25	.97292	84	121.67525	.13013
					250	4.4	34.75	27.56	.97208	56	243.23775	.21776
					450	4.2	34.83	27.65	.97111	49	437.55475	.32126
					750	3.8	34.91	27.76	.96970	41	728.67625	.45676
1034	---do-----	42 11	50 50	2, 971	0	2.6	33.79	26.98	.97373	109	0	0
					25	2.3	33.81	27.02	.97358	105	24.34138	.02673
					50	2.2	34.21	27.34	.97316	74	48.67563	.04913
					125	3.4	34.53	27.49	.97270	62	121.64538	.10026
					250	4.4	34.90	27.63	.97201	49	243.18975	.17955
					450	4.8	34.82	27.58	.97119	57	437.50975	.27626
					750	4.5	34.90	27.68	.96978	49	728.65675	.43726
1035	Apr. 23	42 33	51 12	2, 341	0	4.2	33.94	26.95	.97375	111	0	0
					25	2.9	34.00	27.12	.97349	96	24.34050	.02585
					50	2.9	[1] 34.23	27.30	.97320	78	48.67413	.04763
					125	3.1	34.44	27.45	.97273	65	121.64651	.10139
					250	4.0	34.76	27.62	.97202	50	243.19339	.17340
					450	4.0	34.98	27.78	.97099	37	437.49439	.26090
					750	3.5	34.81	27.70	.96975	46	728.60539	.38590
1036	---do-----	42 50	51 28	1, 646	0	1.6	33.67	26.95	.97375	111	0	0
					25	1.5	33.77	27.04	.97356	103	24.34137	.02672
					50	2.1	33.96	27.16	.97333	91	48.67750	.05100
					125	3.1	34.56	27.55	.97264	56	121.65138	.10626
					250	3.2	34.88	27.80	.97184	32	243.17638	.15639
					450	3.7	34.96	27.81	.97096	34	437.45638	.22289
					750	3.4	34.95	27.82	.96963	34	728.54488	.32539

[1] Interpolated.

Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.	Longitude W.	a Depth of water	a_1 Depth	a=meters			a_1=pressure in decibars			
						Temperature	Salinity	δ_t	V	V−V₁	E	E−E₁
		° ′	° ′			° C.	0/00					
1037	Apr. 26	42 11	50 45	3,109	0	3.2	33.70	26.85	0.97385	121	0	0
					25	2.8	34.17	27.26	.97336	83	24.34012	.02547
					50	2.2	34.25	27.37	.97313	71	48.67124	.04474
					125	3.0	34.45	27.47	.97272	64	121.64062	.09550
					250	5.2	35.01	27.68	.97198	46	243.18437	.16438
					450	4.1	34.97	27.77	.97100	38	437.48237	.24888
					750	3.9	34.99	27.81	.96965	36	728.57987	.36038
1038	...do.....	42 13	51 32	3,475	0	4.2	33.58	26.60	.97409	145	0	0
					25	3.8	33.72	26.86	.97373	120	24.34775	.03310
					50	3.7	33.86	26.98	.97350	108	48.68812	.06162
					125	6.2	34.88	27.45	.97275	67	121.67250	.12738
					250	5.2	34.97	27.68	.97198	46	243.21812	.19813
					450	4.6	34.97	27.73	.97105	43	437.52112	.28763
					750	4.1	35.00	27.80	.96966	37	728.62762	.40813
1039	...do.....	42 31	51 31	2,880	0	3.8	33.77	26.85	.97385	121	0	0
					25	1.6	33.75	27.02	.97358	105	24.34287	.02822
					50	1.7	33.94	27.17	.97332	90	48.67912	.05262
					125	3.8	34.61	27.52	.97267	59	121.65374	.10862
					250	3.0	34.63	27.61	.97203	51	243.19749	.17750
					450	3.0	34.89	27.82	.97094	32	437.49449	.26100
					750	3.6	34.91	27.78	.96967	38	728.58599	.36650
1040	Apr. 27	42 25	51 19	2,743	0	1.0	33.56	26.91	.97379	115	0	0
					25	.2	33.94	27.26	.97336	83	24.33937	.02472
					50	.4	34.05	27.34	.97316	74	48.67087	.04437
					125	1.8	34.43	27.55	.97264	56	121.63837	.09325
					250	2.8	34.78	27.75	.97189	37	243.17149	.15150
					450	3.2	34.87	27.79	.97097	35	437.45749	.22400
					750	3.2	34.88	27.80	.96964	35	728.54899	.32950
1041	May 5	43 38	49 14	136	0	2.0	32.97	26.37	.97430	166	0	0
					10	.9	32.90	26.38	.97424	164	9.74270	.01650
					25	−.1	32.99	26.51	.97406	153	24.35495	.04030
					50	−1.0	33.04	26.58	.97387	145	48.70407	.07757
					75	−1.1	33.22	26.73	.97362	131	73.04769	.11215
					100	−1.1	33.28	26.78	.97347	128	97.38631	.14456
					125	−.8	33.46	26.92	.97322	114	121.71993	.17481
1042	May 6	42 36	49 18	2,560	0	7.6	33.64	26.29	.97438	174	0	0
					25	−.8	33.31	26.80	.97379	126	24.35225	.03760
					50	1.2	33.68	26.99	.97349	107	48.69325	.06675
					125	3.4	34.44	27.42	.97276	68	121.67762	.13250
					250	3.0	34.61	27.60	.97203	51	243.22699	.20700
					450	3.4	34.75	27.67	.97109	47	437.53899	.30550
					750	3.3	34.95	27.84	.96960	31	728.64249	.42300
1043	May 8	43 00	49 48	248	0	2.5	33.03	26.37	.97431	167	0	0
					25	−.2	33.09	26.59	.97399	146	24.35375	.03910
					50	−1.0	33.18	26.70	.97376	134	48.70062	.07412
					75	−1.0	33.30	26.79	.97357	126	72.04224	.10670
					125	−1.0	33.48	26.94	.97320	112	121.71149	.16637
					200	.2	33.79	27.14	.97267	93	194.68161	.24312
					225	1.2	34.08	27.32	.97239	76	218.99486	--------
1044	...do.....	43 03	49 45	184	0	1.8	33.02	26.42	.97426	162	0	0
					25	−.6	33.08	26.60	.97398	145	24.35300	.03835
					75	−1.0	33.22	26.73	.97362	131	73.04300	.10746
					150	−.8	33.50	26.95	.97308	111	146.71050	--------
					175	1.0	33.58	26.92	.97299	113	171.03637	--------
1045	May 9	43 14	49 50	70	0	1.8	32.99	26.39	.97429	165	0	0
					15	.6	33.01	26.49	.97412	155	14.61307	.02393
					25	−.5	33.10	26.61	.97397	144	24.35352	.03887
					50	−.7	33.11	26.63	.97383	141	48.70102	.07452
1046	May 10	42 56	49 21	1,600	0	1.5	32.90	26.35	.97432	168	0	0
					25	.0	32.97	26.49	.97408	155	24.35500	.04035
					50	−.8	33.31	26.79	.97368	126	48.70200	.07550
					125	−1.5	34.33	27.64	.97253	45	121.68487	.13975
					250	2.8	34.61	27.62	.97201	49	243.21862	.19863
					450	3.2	34.76	27.70	.97106	44	437.52562	.29213
					750	3.2	34.79	27.72	.96962	43	728.64262	.42313
1047	May 11	42 40	49 25	1,920	0	2.0	32.80	26.24	.97443	179	0	0
					25	2.0	33.02	26.40	.97417	164	24.35750	.04285
					50	−.3	33.17	26.67	.97379	137	48.70700	.08050
					125	1.1	33.93	27.20	.97296	88	121.71012	.16500
					250	−.1	34.51	27.74	.97188	36	243.26262	.24263
					450	3.3	34.76	27.69	.97107	45	437.55762	.32413
					750	4.0	34.93	27.75	.96971	42	728.67462	.45513

Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.	Longitude W.	*a* Depth of water	a_1 Depth	*a*=meters Temperature	*a*=meters Salinity	δ_t	a_1=pressure in decibars V	$V-V_1$	E	$E-E_1$
		° ′	° ′			° C.	0/00					
1048	May 12	42 44	49 53	1,460	0	2.5	32.81	26.20	0.97447	183	0	0
					25	1.0	32.89	26.37	.97420	167	24.35837	.04372
					50	−.8	33.30	26.78	.97369	127	48.70699	.08049
					125	2.2	34.18	27.32	.97286	78	121.70261	.15749
					250	2.2	34.55	27.61	.97202	50	243.25761	.23762
					450	2.1	34.74	27.78	.97098	36	437.55761	.32412
					750	3.2	34.87	27.79	.96965	36	728.65211	.43262
1049	May 20	42 43	50 27	1,645	0	1.6	33.06	26.46	.97422	158	0	0
					25	−.9	33.26	26.76	.97383	130	24.35062	.03597
					50	−1.1	33.39	26.88	.97359	117	48.69337	.06687
					125	−.7	33.41	26.88	.97326	118	121.70024	.15512
					250	1.2	33.70	27.01	.97259	107	243.31586	.29587
					450	2.9	34.62	27.62	.97113	51	437.68786	.45437
					750	3.1	34.94	27.85	.96960	31	728.79736	.56387
1050	May 21	42 45	51 04	1,645	0	3.1	33.05	26.34	.97433	169	0	0
					25	2.1	33.11	26.47	.97410	157	24.35537	.04072
					50	.0	33.05	26.56	.97390	148	48.70537	.07887
					125	−1.1	33.48	26.95	.97319	111	121.72124	.17612
					250	2.4	33.43	26.71	.97287	135	243.34999	.33000
					450	3.3	34.86	27.77	.97099	37	437.73599	.50250
					750	3.3	34.96	27.85	.96960	31	728.82449	.60500
1051	May 23	42 07	51 39	3,509	0	2.9	33.02	26.34	.97433	169	0	0
					25	2.7	33.10	26.42	.97415	162	24.35600	.04135
					50	2.8	33.55	26.77	.97370	128	48.70412	.07762
					125	3.3	[1]33.75	26.88	.97327	119	121.71549	.17037
					250	4.5	34.60	27.44	.97219	67	243.30674	.28675
					450	3.6	34.74	27.64	.97112	50	437.63774	.40425
					750	3.5	34.84	27.73	.96971	42	728.76224	.44275
1052	May 24	42 40	49 53	2,110	0	1.0	32.96	26.42	.97426	162	0	0
					25	.0	33.04	26.54	.97403	150	24.35362	.03897
					50	1.9	33.83	27.06	.97343	101	48.69687	.07037
					125	1.9	[1]34.00	27.20	.97297	89	121.68687	.14175
					250	1.9	34.45	27.56	.97207	55	243.25187	.23188
					450	3.0	34.81	27.76	.97100	38	437.55887	.32538
					750	3.2	34.87	27.79	.96965	36	728.65637	.43688
1053	May 25	42 18	51 13	2,744	0	5.8	33.38	26.32	.97435	171	0	0
					25	5.9	33.46	26.37	.97420	167	24.35687	.04222
					50	2.2	33.47	26.75	.97371	129	48.70574	.07924
					125	4.0	34.35	27.29	.97289	81	121.70324	.15812
					250	4.0	34.83	27.67	.97198	46	243.25761	.23762
					450	3.5	34.89	27.77	.97099	37	437.55461	.32112
					750	4.2	35.00	27.78	.96968	39	728.65511	.43562
1054	May 27	42 52	50 13	510	0	4.9	32.88	26.03	.97463	199	0	0
					25	.2	33.06	26.55	.97402	149	24.35812	.04347
					50	−.2	33.30	26.76	.97371	129	48.70474	.07824
					125	−.2	33.67	27.07	.97309	101	121.70974	.16462
					250	1.3	34.41	27.57	.97206	54	243.28161	.26162
					450	2.5	34.82	27.81	.97095	44	437.58261	.34912
1055	May 28	42 32	50 27	2,010	0	3.0	32.88	26.22	.97445	181	0	0
					25	3.0	33.40	26.63	.97395	142	24.35500	.04035
					50	1.2	34.09	27.32	.97318	76	48.69412	.06762
					125	2.9	34.64	27.64	.97255	47	121.65899	.11387
					250	2.9	34.74	27.71	.97193	41	243.18899	.16900
					450	3.2	34.95	27.86	.97091	29	437.47299	.23959
					750	3.2	34.97	27.87	.96958	29	728.54649	.32700
1056	May 29	42 57	49 50	183	0	4.6	33.16	26.28	.97439	175	0	0
					25	2.2	33.20	26.53	.97404	151	24.35537	.04072
					50	1.0	33.25	26.66	.97380	138	48.70337	.07687
					75	−.2	33.35	26.81	.97355	124	73.04524	.10970
					100	−.8	33.37	26.85	.97340	121	97.38211	.14036
					125	−.3	33.56	26.98	.97317	109	121.71423	.16911
1057	May 31	42 56	50 00	140	0	3.0	33.11	26.39	.97429	165	0	0
					25	.0	33.20	26.68	.97390	137	24.35237	.03772
					50	−1.0	33.50	26.96	.97352	110	48.69512	.06862
					75	−1.1	33.61	27.05	.97332	101	73.03062	.09508
					100	−.8	33.64	27.06	.97320	101	97.36212	.12037
					125	−.5	33.74	27.13	.97303	95	121.68999	.14487
1058	June 1	42 51	49 23	1,462	0	3.2	32.93	26.20	.97447	183	0	0
					25	1.6	33.45	26.77	.97382	129	24.35362	.03897
					50	1.1	34.06	27.31	.97319	77	48.69124	.06474
					125	2.7	34.58	27.60	.97259	51	121.65799	.11287
					250	3.0	34.75	27.71	.97193	41	243.19049	.17050
					450	3.1	34.85	27.78	.97098	36	437.48149	.24800
					750	3.2	34.90	27.81	.96963	34	728.57299	.35350

[1] Interpolated.

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Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.		Longitude W.		a Depth of water	a_1 Depth	a = meters			a_1 = pressure in decibars			
								Temperature	Salinity	δ_t	V	V-V₁	E	E-E₁
		°	′	°	′			° C.	*0/00*					
1059	June 4	42	26	49	48	2,927	0	3.1	32.81	26.16	0.97451	187	0	0
							25	.2	33.15	26.62	.97396	143	24.35587	.04122
							50	.0	33.70	27.08	.97341	99	48.69799	.07149
							125	3.1	34.58	27.56	.97263	55	121.67449	.12937
							250	3.1	34.75	27.70	.97194	42	243.21011	.19012
							450	3.4	34.87	27.77	.97099	37	437.50311	.26962
							750	3.1	34.90	27.82	.96962	33	728.59461	.37512
1060	June 7	42	27	49	46	2,744	0	4.0	32.85	26.10	.97456	192	0	0
							25	1.1	33.31	26.70	.97388	135	24.35550	.04085
							50	1.0	33.78	27.09	.97340	98	48.69650	.07000
							125	2.1	34.48	27.56	.97263	55	121.67262	.12750
							250	3.0	34.74	27.70	.97194	42	243.20824	.18825
							450	3.2	34.86	27.78	.97098	36	437.50024	.26675
							750	3.2	34.88	27.80	.96964	35	728.59324	.37375
1061	June 8	41	20	48	12	3,382	0	9.1	33.19	25.70	.97494	230	0	0
							25	7.5	33.22	25.97	.97458	205	24.36900	.05435
							50	5.2	33.27	26.31	.97413	171	48.72787	.10137
							125	4.9	33.77	26.74	.97340	132	121.76024	.21512
							250	3.0	34.45	27.47	.97216	64	243.35773	.33774
							450	4.9	34.89	27.62	.97115	53	437.68873	.45524
							750	4.0	34.92	27.74	.96972	43	728.81924	.59975
1062	June 9	42	27	49	19	2,744	0	4.9	32.78	25.95	.97471	207	0	0
							25	1.8	33.04	26.44	.97413	160	24.36050	.04585
							50	1.1	33.85	27.14	.97335	93	48.70400	.07750
							125	2.1	34.40	27.50	.97269	61	121.68050	.13538
							250	3.0	34.62	27.61	.97202	50	243.22487	.20488
							450	4.1	34.91	27.72	.97105	43	437.53187	.29838
							750	4.9	34.92	27.65	.96982	53	728.66237	.44288
1063	June 10	42	55	50	23	346	0	2.2	33.08	26.44	.97424	160	0	0
							25	.1	33.13	26.61	.97397	144	24.35262	.03797
							50	.0	33.28	26.74	.97372	130	48.69874	.07224
							125	.2	33.81	27.16	.97300	92	121.70074	.15562
							250	1.4	34.24	27.43	.97219	67	243.27511	.25512
1064	June 11	42	42	48	40	2,927	0	6.0	32.93	25.94	.97471	207	0	0
							25	5.2	33.21	26.26	.97430	177	24.36262	.04797
							50	1.8	33.73	26.99	.97349	107	48.70999	.08349
							125	3.0	34.45	27.47	.97272	64	121.69286	.14774
							250	2.9	34.66	27.65	.97198	46	243.23661	.21762
							450	4.0	34.92	27.75	.97102	40	437.53661	.30312
							750	[2] 4.3	34.97	27.75	.96971	42	728.64611	.42662
1065	June 12	42	55	48	30	2,812	0	7.2	33.22	26.01	.97465	201	0	0
							25	5.2	33.52	26.50	.97407	154	24.35900	.04435
							50	1.4	34.49	27.63	.97288	46	48.69587	.06937
							125	4.1	34.68	27.54	.97265	57	121.65324	.10812
							250	4.2	34.88	27.74	.97191	39	243.18824	.16825
							450	4.0	34.88	27.71	.97106	44	437.48524	.25175
							750	4.6	34.89	27.71	.96977	48	728.60974	.39025
							1000	4.5	34.88	27.66	.96873	54	970.92224	.51775
							1500	4.1	34.86	27.69	.96657	------	1454.74724	--------
							1700	3.0	34.86	27.80	.96559	------	1647.96324	--------
1066	June 13	43	00	49	40	822	0	2.8	32.80	26.17	.97450	186	0	0
							25	.2	32.92	26.44	.97413	160	24.35787	.04322
							50	−1.0	33.34	26.83	.97364	122	48.70499	.07849
							125	.0	33.69	27.07	.97309	101	121.70736	.16224
							250	2.0	34.42	27.53	.97210	58	243.28173	.26174
							450	3.2	34.81	27.74	.97102	40	437.59373	.36024
							700	3.2	34.85	27.78	.96989	60	680.20748	.45799
1067	June 15	42	07	48	50	3,209	0	7.0	33.04	25.91	.97474	210	0	0
							25	3.9	33.29	26.46	.97411	158	24.36062	.04597
							50	1.0	33.76	27.07	.97342	100	48.70474	.07824
							125	2.4	34.42	27.49	.97270	62	121.68424	.13912
							250	3.2	34.73	27.68	.97196	44	243.22549	.20550
							450	4.1	[1] 34.86	27.68	.97109	47	437.53049	.29700
							750	4.0	34.85	27.69	.96977	48	728.65949	.44000
1068	June 16	42	30	49	30	2,559	0	5.8	33.18	26.16	.97451	187	0	0
							25	2.6	33.71	26.99	.97361	108	24.35150	.03685
							50	3.9	34.29	27.25	.97324	82	48.68712	.06062
							125	3.8	34.56	27.48	.97271	63	121.66024	.11512
							250	4.1	34.82	27.65	.97199	47	243.20399	.18400
							450	3.5	34.84	27.73	.97103	41	437.50599	.27250
							750	4.6	34.92	27.68	.96979	50	728.62899	.40950

[1] Interpolated. [2] Exterpolated.

Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.	Longitude W.	a Depth of water	a_1 Depth	a=meters Temperature	Salinity	δ_t	a_1=pressure in decibars V	$V-V_1$	E	$E-E_1$
		° ′	° ′			° C.	0/00					
1069	June 19	41 57	48 00	3,749	0	11.4	33.15	25.29	0.97533	269	0	0
					25	5.9	33.42	26.33	.97423	170	24.36950	.05485
					50	3.7	33.76	26.85	.97362	120	48.71762	.09112
					125	4.2	34.48	27.37	.97281	73	121.70874	.16362
					250	4.7	34.85	27.61	.97204	96	243.26186	.24187
					450	4.2	34.91	27.71	.97106	44	437.57186	.33837
					750	4.0	34.95	27.77	.96969	40	728.68436	.46487
1070	June 21	42 45	49 11	2,378	0	6.2	33.28	26.19	.97488	184	0	0
					25	3.3	33.56	26.73	.97385	132	24.35412	.03947
					50	2.9	34.03	27.18	.97333	91	48.69387	.06737
					125	2.8	34.54	27.56	.97263	55	121.66737	.12225
					250	2.8	34.81	27.78	.97186	34	243.19799	.17800
					450	3.6	34.87	27.75	.97102	40	437.48599	.25250
					750	3.6	34.91	27.79	.96966	37	728.58799	.36850
1071	June 25	43 07	48 53	2,269	0	9.0	33.35	25.85	.97480	216	0	0
					25	5.0	33.41	26.44	.97413	160	24.36162	.04697
					50	2.4	33.90	27.08	.97341	99	48.70587	.07937
					125	3.2	34.55	27.53	.97266	58	121.68349	.13837
					250	4.2	34.83	27.65	.97200	48	243.22474	.20475
					450	3.8	34.88	27.73	.97104	42	437.52784	.29435
					750	3.6	34.88	27.75	.96970	41	728.63974	.42025
1072	June 26	42 13	48 40	3,199	0	17.4	34.81	25.30	.97532	268	0	0
					25	13.9	34.82	26.09	.97446	193	24.37225	.05760
					50	13.2	34.96	26.34	.97411	169	48.72937	.10287
					125	11.8	35.21	26.81	.97335	127	121.75912	.21400
					250	7.8	35.39	27.63	.97203	51	243.34537	.32538
					450	7.6	35.42	27.69	.97112	50	437.66037	.42688
					750	4.2	35.43	28.12	.96936	7	728.73237	.51288
1073	June 28	42 03	49 40	3,247	0	6.1	32.63	25.68	.97496	232	0	0
					25	2.5	32.92	26.29	.97427	174	24.36537	.05072
					50	.2	33.29	26.74	.97372	130	48.71524	.08874
					125	2.0	33.98	27.18	.97299	91	121.71686	.17174
					250	2.6	34.52	27.56	.97207	55	243.28311	.26312
					450	3.0	34.72	27.69	.97107	45	437.59711	.36362
					750	3.2	34.82	27.75	.96969	40	728.71111	.49162
1074	June 30	43 08	50 50	101	0	10.8	32.96	25.25	.97437	173	0	0
					25	3.0	33.03	26.34	.97422	169	24.35737	.04272
					50	−.3	33.23	26.71	.97375	133	48.70699	.08049
					75	2.0	33.88	27.10	.97328	97	73.04486	.10932
					100	3.4	34.20	27.23	.97305	86	97.37372	.13217
1075	July 1	42 05	50 20	3,290	0	19.8	34.73	24.66	.97594	330	0	0
					25	18.4	35.00	25.20	.97532	279	24.39075	.07610
					50	15.2	35.41	26.27	.97418	176	48.75950	.13300
					125	13.0	35.44	26.75	.97342	134	121.79450	.24938
					250	11.8	35.48	27.02	.97263	111	243.42262	.40263
					450	7.2	35.60	27.89	.97092	30	437.77762	.54413
					750	3.4	35.66	28.39	.97909	−20	728.77912	.55963
1076	July 5	42 32	49 04	2,779	0	11.2	32.96	25.18	.97544	280	0	0
					25	2.8	33.46	26.70	.97388	135	24.36650	.05185
					50	1.6	33.59	26.89	.97358	116	48.70975	.08325
					125	3.0	34.51	27.51	.97268	60	121.69450	.14938
					250	4.0	34.84	27.68	.97197	45	243.23512	.21513
					450	4.0	34.94	27.76	.97101	39	437.53312	.29963
					750	4.0	34.94	27.76	.96970	41	728.63962	.42013
1077	July 6	43 00	49 05	2,560	0	11.8	33.00	25.10	.97551	287	0	0
					25	2.1	33.50	26.78	.97381	128	24.36650	.05185
					50	4.0	34.22	27.19	.97330	88	48.70537	.07887
					125	4.0	34 63	27.51	.97268	60	121.67962	.13450
					250	4.0	34.78	27.63	.97201	49	243.22274	.20275
					450	4.1	34.89	27.71	.97106	44	437.52974	.39625
					750	4.0	34.91	27.74	.96972	43	728.64674	.42735
1078	July 7	43 20	49 17	915	0	7.5	32.81	25.64	.97500	236	0	0
					25	7.5	33.81	26.44	.97413	160	24.36412	.04947
					50	5.4	34.34	27.13	.97336	94	48.70774	.08124
					125	5.2	34.71	27.45	.97273	65	121.68611	.14099
					250	4.5	34.84	27.63	.97201	49	243.23236	.21237
					450	3.4	34.84	27.74	.97102	40	437.53536	.30187
					750	2.3	34.85	27.85	.96958	29	728.62536	.40587
1079	July 8	41 44	49 00	3,290	0	10.8	33.19	25.45	.97518	254	0	0
					25	8.8	33.42	25.93	.97461	208	24.37237	.05772
					50	3.8	33.75	26.84	.97363	121	48.72537	.09887
					125	2.7	34.33	27.40	.97278	70	121.71574	.17062
					250	2.8	34.62	27.62	.97201	49	243.26511	.24512
					450	3.5	34.86	27.75	.97101	39	437.56711	.33362
					750	3.8	34.92	27.77	.96969	40	728.67211	.45262

Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.		Longitude W.		a Depth of water	a_1 Depth	a = meters: Temperature	Salinity	δ_t	a_1 = pressure in decibars: V	$V-V_1$	E	$E-E_1$
		°	′	°	′			° C.	0/00					
1080	July 9	41	36	48	32	3,430	0	11.4	32.82	25.03	0.97558	294	0	0
							25	8.9	33.20	25.74	.97479	226	24.37962	.06497
							50	4.2	33.44	26.56	.97390	148	48.73824	.11174
							125	2.7	34.16	27.26	.97292	84	121.74399	.19887
							250	4.4	34.71	27.54	.97210	58	243.30774	.28775
							450	3.9	34.87	27.72	.97105	43	437.62274	.38925
							750	[2] 3.9	34.91	27.75	.96971	42	728.73674	.51725
1081	July 13	42	00	48	40	3,239	0	11.9	32.92	25.02	.97559	295	0	0
							25	6.0	33.24	26.19	.97437	184	24.37450	.05985
							50	4.2	33.74	26.79	.97368	126	48.72512	.09862
							125	2.1	34.36	27.47	.97272	64	121.71512	.17000
							250	3.2	34.65	27.61	.97202	50	243.26137	.24138
							450	4.0	34.85	27.69	.97108	46	437.57137	.33788
							750	4.0	34.92	27.73	.96973	44	728.69287	.47338
1082	July 14	41	34	48	11	3,381	0	17.7	34.26	24.80	.97580	316	0	0
							25	17.3	34.57	25.40	.97512	259	24.38650	.07185
							50	14.8	34.65	25.70	.97472	230	48.75950	.13300
							125	[1] 3.6	34.64	27.56	.97263	55	121.78512	.24000
							250	3.8	34.64	27.54	.97210	58	243.33074	.31075
							450	4.4	34.71	27.54	.97122	60	437.66274	.42925
							750	4.4	34.95	27.73	.96974	45	728.80624	.58675
1083	July 15	41	32	49	07	3,327	0	13.2	33.07	24.88	.97572	308	0	0
							25	6.7	33.22	26.08	.97447	194	24.37737	.06272
							50	2.6	33.83	27.00	.97348	106	48.72674	.10024
							125	3.1	34.49	27.49	.97270	62	121.70849	.16337
							250	3.7	34.76	27.65	.97199	47	243.25161	.23162
							450	4.3	34.93	27.72	.97105	43	437.55561	.32212
							750	4.2	34.95	27.75	.96971	42	728.66961	.45012
1084	July 16	41	45	48	50	3,107	0	13.4	33.06	24.81	.97579	315	0	0
							25	6.8	33.38	26.20	.97436	183	24.37687	.06222
							50	3.4	33.94	27.02	.97346	104	48.72462	.09812
							125	2.9	34.46	27.48	.97271	63	121.70599	.16087
							250	3.5	34.70	27.62	.97202	50	243.25162	.23163
							450	3.7	34.83	27.70	.97107	45	437.56062	.32713
							750	3.7	34.89	27.75	.96971	42	728.67762	.45813
1085	July 18	42	01	49	29	3,290	0	14.0	32.89	24.59	.97600	336	0	0
							25	4.2	33.31	26.45	.97412	159	24.37650	.06185
							50	1.9	33.91	27.13	.97336	94	48.72000	.09350
							125	2.8	34.42	27.46	.97273	65	121.69837	.15325
							250	4.0	34.73	27.59	.97205	53	243.24712	.22713
							450	3.6	34.75	27.65	.97115	53	437.56312	.32963
							750	3.6	34.73	27.63	.96981	52	728.70112	.48163
1086	July 20	41	18	48	43	3,343	0	14.6	32.96	24.51	.97608	344	0	0
							25	6.4	33.30	26.19	.97437	184	24.38062	.06597
							50	2.6	33.69	26.90	.97357	115	48.72987	.10337
							125	3.7	34.45	27.41	.97277	69	121.71762	.17250
							250	3.5	34.61	27.55	.97209	57	243.27137	.25138
							450	3.5	34.73	27.64	.97112	50	437.59267	.35918
							750	3.4	34.77	27.69	.96976	47	728.72437	.50488
1087	July 21	40	57	48	55	3,290	0	13.3	32.84	24.68	.97592	328	0	0
							25	9.8	33.37	25.73	.97480	227	24.38400	.06935
							50	5.7	33.01	26.05	.97438	196	48.74875	.12225
							125	2.3	33.11	26.46	.97367	159	121.80062	.25550
							250	4.8	34.80	27.56	.97209	57	243.41062	.39063
							450	4.7	34.70	27.49	.97128	66	437.74762	.51413
							750	4.2	34.90	27.71	.96975	46	728.90212	.68263
1088	July 23	41	48	49	15	3,290	0	15.5	32.88	24.66	.97594	330	0	0
							25	2.4	32.94	26.32	.97424	171	24.37725	.06260
							50	2.2	33.60	26.85	.97362	120	48.72550	.09900
							125	5.1	33.96	26.85	.97330	122	121.73500	.18988
							250	4.0	34.67	27.54	.97210	58	243.32250	.30251
							450	3.8	34.77	27.65	.97111	49	437.64350	.41001
							750	3.5	34.74	27.65	.96979	50	728.77850	.55901
1089	July 24	42	11	49	29	3,109	0	15.3	33.34	24.63	.97596	332	0	0
							25	5.0	33.49	26.51	.97406	153	24.37525	.06060
							50	4.8	33.75	26.73	.97373	131	48.72262	.09612
							125	4.7	34.55	27.38	.97280	72	121.71749	.17237
							250	5.0	34.86	27.59	.97206	54	243.27124	.25125
							450	5.0	34.80	27.56	.97121	59	437.59824	.36475
							750	3.8	34.73	27.62	.96983	54	728.75424	.53475
1090	July 26	42	20	49	45	3,019	0	14.9	32.80	24.32	.97626	362	0	0
							25	7.4	33.12	25.90	.97464	211	24.38625	.07160
							50	4.8	33.90	26.85	.97362	120	48.73950	.11300
							125	2.4	34.41	27.48	.97271	63	121.72687	.18175
							250	2.4	34.54	27.59	.97204	52	243.27374	.25375
							450	3.4	34.75	27.67	.97109	47	437.58674	.35325
							750	4.2	34.78	27.62	.96983	54	728.72474	.50525

[1] Interpolated. [2] Exterpolated.

Oceanographic station data and dynamic calculations, 1929—Continued

Station	Date	Latitude N.	Longitude W.	a Depth of water	a_1 Depth	a=meters: Temperature	a=meters: Salinity	a=meters: δ_t	a_1=pressure in decibars: V	a_1=pressure in decibars: $V-V_1$	a_1=pressure in decibars: E	a_1=pressure in decibars: $E-E_1$
		° ′	° ′			° C.	0/00					
1091	July 28	43 26	49 10	1,096	0	14.2	32.92	24.53	0.97606	342	0	0
					25	7.0	33.36	26.16	.97440	187	24.38075	.06610
					50	7.3	33.68	26.36	.97410	168	48.73700	.10050
					125	7.7	34.27	26.75	.97340	132	121.76825	.22313
					250	4.9	34.85	27.61	.97204	52	243.35825	.33826
					450	[1] 3.1	34.63	27.60	.97115	53	437.67725	.44376
					750	3.4	34.65	27.59	.96985	56	728.82725	.60776
1092	July 29	43 40	49 03	913	0	14.8	33.73	25.05	.97556	292	0	0
					25	11.6	35.03	26.71	.97387	134	24.36787	.05322
					50	11.8	35.22	26.84	.97364	122	48.71174	.08524
					125	10.2	35.17	27.07	.97311	103	121.71486	.16974
					250	8.6	34.77	27.02	.97262	110	243.32298	.30299
					450	4.3	34.84	27.65	.97111	49	437.69598	.46249
1093	July 30	43 47	49 02	1,280	0	10.3	32.33	24.83	.97577	313	0	0
					25	5.3	32.56	25.72	.97481	228	24.38225	.06760
					50	5.3	32.59	25.75	.97466	224	48.75062	.12412
					125	4.8	33.27	26.36	.97377	169	121.81674	.27162
					250	4.0	34.71	27.58	.97206	54	243.43111	.41112
					450	4.3	34.83	27.65	.97111	49	437.74811	.51462
					750	3.8	34.82	27.69	.96977	48	728.88011	.66062
1094	July 31	43 40	49 00	982	0	11.0	32.61	24.94	.97566	302	0	0
					25	3.9	33.79	26.85	.97374	121	24.36750	.05285
					50	4.6	34.50	27.34	.97316	74	48.70375	.07725
					125	4.5	34.55	27.40	.97278	70	121.67650	.13138
					250	4.6	34.82	27.60	.97205	53	243.22837	.20838
1095	Aug. 2	43 41	49 05	783	0	10.7	32.35	24.79	.97581	317	0	0
					25	5.0	32.96	26.09	.97446	193	24.37837	.06372
					50	−.4	33.21	26.70	.97376	134	48.73112	.10462
					125	2.5	34.33	27.42	.97278	70	121.72637	.18125
					250	2.9	34.51	27.52	.97211	59	243.28199	.26200
					450	3.7	34.64	27.55	.97121	59	437.61399	.38050
					750	4.2	34.68	27.58	.96987	58	728.77599	.55650

[1] Interpolated.

TREASURY DEPARTMENT :: UNITED STATES COAST GUARD

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